

PRIVATE
DEPOSITORY

MONTHLY NOTICES
OF THE
ROYAL ASTRONOMICAL SOCIETY.

VOL. LIX. No. 6. MARCH 1899.

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OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LIX.

MARCH 10, 1899.

No. 6

Professor G. H. DARWIN, M.A., LL.D., F.R.S., President, in the Chair.

Col. Thomas Davies Sewell, 29 Grosvenor Road, S.W.,
was balloted for and duly elected a Fellow of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

The Rev. Edward Lyon Berthon, M.A., St. Margaret's, Cupernham, Romsey, Hants (proposed by Sir Howard Grubb) ;

The Rev. Theodore Evelyn Reece Phillips, M.A. (Oxon.), Hendford Vicarage, Yeovil, Somerset (proposed by W. F. Denning).

One hundred and twenty presents were announced as having been received since the last ordinary meeting, including, amongst others :—

A. Berry, A short history of Astronomy, presented by the author ; V. de Campigneulles, Observations of the eclipse of 1898 January 22, by the Jesuit Fathers of the Western Bengal Mission, presented by St. Xavier's College Observatory ; A. H. Fison, Recent advances in Astronomy, and A. Laussedat, Recherches sur les instruments topographiques, tome 1, presented by the authors ; Columbia University Observatory, New York, Collected

Contributions, vol. i., presented by the Observatory ; Potsdam Observatory, Publications, vol. 12, pt. 1, vol. 13, presented by the Observatory ; E. J. Spitta, Photo-micrography, presented by the author ; Mrs. Todd, Corona and Coronet, being a narrative of the Amherst Eclipse Expedition to Japan, 1896, presented by the author ; The Second Washington Catalogue of Stars, presented by the U.S. Naval Observatory ; Photographischer Mond-Atlas, part 4, presented by L. Weinek ; Photographs of the total solar eclipse of 1898 January 22, presented by C. Burckhalter ; Photographs of artificial lunar formations, presented by S. H. R. Salmon ; Photographs of fields of stars showing trails of minor planets, &c., presented by Max Wolf.

*Report of the Proceedings of the Sydney Observatory for 1898.**

Reference was made in the Report for 1897 to the difficulty introduced into our photographic work by the adoption of incandescent gas-burners for illuminating the city. The light given by these incandescent burners is powerfully actinic, and the dust and smoke of a great city reflects enough of this light to fog long-exposure plates.

To avoid this unexpected difficulty, the Government has granted a sum of money for the removal of the star camera from the city to the site selected some years since for the Observatory. The experiments then made proved that the atmosphere was very much clearer than in the city, so much so that a three hours' exposure there was equal to one of five hours in the city. Red-hill, the place referred to, is 615 feet above the sea and eleven miles W.N.W. from the present Observatory.

Measurement of Photographic Plates.—An arrangement has been made by which the measurement of our star plates will at last be undertaken systematically.

The Governments of Victoria and New South Wales have granted the money necessary for measuring the photographic plates, and at a conference of the astronomers of Melbourne and Sydney it was decided to combine the money grants, with the object of making one complete measuring bureau, furnished with the most perfect measuring machines. The work will be done in Melbourne, and the staff is now being trained by Mr. Baracchi.

Transit Circle.—With the transit circle (only one observer) 1,355 transits and 511 meridian zenith distances have been observed. The computations of the meridian observations have

* This report was received unfortunately too late for insertion in the Annual Report of the Council.

been completed, and a large volume of arrears in printing now awaits publication.

The daily determinations of collimation, level, and nadir, for determining the progressive motion of the meridian circle, have been continued.

Double Stars.—With the equatorial (one observer) 98 double stars have been measured. 444 position-angle settings and 458 measures of distance were taken.

Comet *Coddington* was observed, and ninety-eight comparisons made with fifteen stars. The transit circle was used fourteen times to determine the comet's position on the meridian.

Star Camera.—With the star camera 247 photographs were taken with 326 exposures. Of these, 152 are chart plates and eighty-eight catalogue plates, and seven on special subjects.

The year has been remarkably dry and dusty, so much so that many nights were too dusty to permit taking photographs.

Meteorology.—The meteorological work has been carried on as usual. The increase in the number of stations goes on, and now they number 1,610. The volume for 1897 has been printed and distributed, and that for 1898 is nearly ready for the press.

During the year there has been added to the recording machines at the Observatory a new form of recording thermometer, which is as sensitive as the ordinary mercurial thermometer.

The usual inspection of meteorological stations has been carried out.

General.—During the year three books and five pamphlets have been published and distributed—in all 4,620 copies have been sent out; and rain and weather charts to the number of 1,800 copies have been distributed.

985 publications of other Observatories have been received and acknowledged.

Visitors show no sign of falling off, rather the reverse. During the year 1,207 visitors came to the Observatory. This is the penalty of having the Observatory in the heart of a large city.

Determination of the Diameter and Compression of the Planet Mars from Observations with the Repsold Heliumeter of the Royal Observatory, Göttingen. (Second Communication.)
By Professor W. Schur.

Near the opposition of the present year the following measurements of the polar and equatorial diameters of the planet Mars were made, the images being steady :—

Date, 1899.	Mean Time, Göttingen. h m	Arcographic Latitude. °	Measured Diameter. "		Diameter at Mean Distance from the Sun. "	Mean of h and v.
January 21	8 44	90	14'74	h	6'33	6'23
			14'50	v	6'23	
		0	14'62	h	6'28	6'34
			14'90	v	6'40	
		0	14'63	v	6'29	6'28
			14'59	h	6'27	
		90	14'33	v	6'16	6'18
			14'43	h	6'20	
		90	14'52	h	6'24	6'38
			15'15	v	6'51	
		0	14'40	h	6'19	6'40
			15'36	v	6'60	
		0	15'41	v	6'62	6'46
			14'63	h	6'29	
		90	14'75	v	6'34	6'26
			14'36	h	6'17	
January 23	13 15	90	14'59	h	6'30	6'24
			14'28	v	6'17	
		0	14'24	h	6'15	6'22
			14'56	v	6'29	
		0	14'21	v	6'14	6'21
			14'51	h	6'27	
		90	13'87	v	5'99	6'05
			14'12	h	6'10	
		90	13'87	h	5'99	6'07
			14'23	v	6'14	
		0	14'23	h	6'14	6'17
			14'36	v	6'20	
		0	14'26	v	6'16	6'14
			14'14	h	6'11	

Date, 1899.	Mean Time, Göttingen. h m	Areographic Latitude.	Measured Diameter.		Diameter at Mean Distance from the Sun.	Mean of <i>h</i> and <i>v</i> .
January 23	13 15	90	13''90	<i>v</i>	6''00	5''97
			13'76	<i>h</i>	5'94	
January 26	12 19	90	14'01	<i>h</i>	6'11	6'13
			14'07	<i>v</i>	6'14	
		0	14'35	<i>h</i>	6'26	6'30
			14'53	<i>v</i>	6'34	
		0	14'34	<i>v</i>	6'25	6'22
			14'17	<i>h</i>	6'18	
		90	14'05	<i>v</i>	6'13	6'17
			14'23	<i>h</i>	6'20	
		90	13'96	<i>h</i>	6'09	6'11
			14'03	<i>v</i>	6'12	
		0	14'30	<i>h</i>	6'24	6'32
			14'65	<i>v</i>	6'39	
		0	14'41	<i>v</i>	6'28	6'30
			14'47	<i>h</i>	6'31	
		90	14'16	<i>v</i>	6'17	6'17
			14'14	<i>h</i>	6'17	

As in the former communication (*Monthly Notices*, 1897, January), *h* and *v* denote the measurements with apparent horizontal and vertical motion of the images by means of the ocular reversing prism. The small correction for defect of illumination is taken from the ephemeris of Mr. Crommelin in the *Monthly Notices*. On January 21 in the second part the images were sometimes a little unsteady and blurred; hence the larger discrepancies.

If the results obtained 1896 December are combined with those of the present year, we have the following summary, including some small later corrections:—

	2 <i>a</i> .	2 <i>b</i> .	Diff.	$a = \frac{a-b}{a}$	
1896 Dec. 2	6''265	6''125	0''140	1 : 45	
11	6'310	6'135	0'175	36	Opposition Dec. 10.
16	6'210	6'095	0'115	54	
17	6'235	6'125	0'110	57	
1899 Jan. 21	6'370	6'263	0'107	60	
23	6'185	6'082	0'103	60	Opposition Jan. 18.
26	6'285	6'145	0'140	45	

The observations of the present year confirm those of 1896, and the planet would therefore have a compression of a fiftieth.

This result is to be preferred to that of earlier researches which have in part led to a similar value, since in the recent observations the use of an ocular reversing prism eliminates those peculiarities of the eyes of the observers which give rise to different results in measuring diameters of discs in different directions with the vertical line. The results of observations with the Göttingen heliometer have therefore a greater weight. (Compare the exhaustive researches of E. Hartwig, *Publication der Astronomischen Gesellschaft*, vol. xv.)

The result of the Göttingen heliometer observations is in conflict with that which Hermann Struve has calculated from his researches on the motions of the apsides of the satellites *Phobos* and *Deimos* (*Astronomische Nachrichten*, vol. cxxxviii, p. 228), i.e. $\frac{1}{190}$. One might be inclined to prefer the result of Struve, as there the compression is deduced from the perturbations in the motions of the satellites, but it should be remembered that the measured positions of the satellites, referred to the centre of the planet, are likewise founded upon comparisons with different points in the circumference of the disc, and that therefore errors may arise similar to those occurring in the heliometer observations. Respecting the latter, I must remark that in the opposition of this year the northern polar snow cap was visible in considerable extension and intensity, and that therefore the measurements of the polar diameter were rather difficult. But, as Hartwig has already shown on p. 54 of his treatise, this disturbing influence would not act in such a way as to diminish the polar diameters, but, on the contrary, to enlarge them, and therefore could not explain that difference.

In a recent publication (*Annals of the Lowell Observatory*, vol. i., "Observations of the Planet Mars during the Opposition of 1894-95," p. 75), Mr. Percival Lowell finds a value for the compression in good accordance with H. Struve, i.e. $\frac{1}{190}$; but it is not shown whether these observations are independent of errors in estimation—which in the case of the Göttingen heliometer measures are provided against by the use of the ocular prism—and I am of opinion that in all researches relating to the form of a celestial body this point is a necessary condition.

To reduce the diameters to the mean distance between Sun and Earth, the foregoing values of $2a$ and $2b$ are to be multiplied by 1.5227, and we have:—

$$2a = 9''.55$$

$$2b = 9''.35.$$

Or, if we decline to adopt the great value of compression, the mean diameter of the planet *Mars* is $9''.45$.

It is to be hoped that observers with other heliometers have taken the opportunity to contribute to the settlement of this question.

1899 February.

The Radiant Point of the April Meteors (Lyrids).

By W. F. Denning.

On Wednesday morning, 1803 April 20,* a brilliant meteoric shower was observed from Richmond, Va., Raleigh, N.C., Wilmington, Del., Schoharie County, N.Y., Portsmouth, N.H., and at several places in Massachusetts. The phenomenon was variously described according to the different impressions received by the observers. One said "the shooting stars were too numerous to be counted"; another stated that "the heavens seemed to be all on fire from the abundance of lucid meteors." The *Virginia Gazette* in alluding to the event said that "from one to three in the morning meteors seemed to fall from every point in the heavens, in such numbers as to resemble a shower of sky-rockets. The inhabitants happened at the same hour to be called from their houses by the fire bell, which was rung on account of a fire which broke out at the Armoury, so that everyone had an opportunity of witnessing this grand scene of Nature."

In 1838 April 20 Professor Wright and an assistant at Knoxville, Ten., counted 154 shooting stars between 10^h and 16^h. In 1839 April 18 Herrick watched for the return of the shower, and in the three hours following midnight he and another observer counted 58 meteors. Herrick placed the radiant at 273°+45° between *Lyra* and the head of *Draco*. In 1842 April 20 he re-observed the shower, and in spite of moonlight 151 meteors were seen by five observers between 10^h 20^m and 16^h. The maximum hourly rate was 55 between 15^h and 16^h, and the

* Ancient showers, probably of Lyrids, are mentioned by Biot, Chasles and Herrick. They have been summarised by Professor H. A. Newton in the *American Journal of Science and Art*, vol. xxxvi., p. 145, and he points out that the time of occurrence of the shower has advanced 24 hours in 60 years, owing to the precession of the equinoxes. The dates and corresponding modern epochs of the ancient displays are as follows:—

Authority.	Date.					
Biot	B.C. 687	March 16	equivalent to A.D. 1850	April 19	9	
Biot	" 15	" 25	" "	" "	" "	19.6
Chasles	A.D. 582	" 31	" "	" "	" "	18.1
Chasles	" 1093	April 9	" "	" "	" "	20.7
Chasles	" 1094	" 10	" "	" "	" "	20.8
Herrick	" 1095	" 9	" "	" "	" "	20.2
Herrick	" 1096	" 10	" "	" "	" "	21.3
Herrick	" 1122	" 10	" "	" "	" "	20.2
Chasles	" 1123	" 11	" "	" "	" "	20.4

Mean date . . . 1850 April 20.1

The conformity of dates renders it extremely probable that the old observations refer to veritable returns of the Lyrids.

radiant point was thought to lie in *Corona Borealis*. The shower was again witnessed in 1849 April 19, when 54 meteors were counted in an hour by Herrick and two others. In 1850 April 20 an extraordinary display of meteors was witnessed at Bombay; and the shower which occurred in 1863, and was favourably seen in England, was judged to equal a moderately strong return of the *Perseids*, for meteors from the *Lyrid* radiant were falling at the rate of about 40 per hour.

Without, however, touching further upon the historical associations of the display it may be said that when in 1866 the April meteoric shower came to be associated with Thatcher's comet, 1861 I., the observed radiant point of the former did not correspond with the computed radiant for the comet to within 7 degrees. Later determinations were somewhat more satisfactory, and I found on closely watching the returns of the shower in 1878-79 and several subsequent years that the cometary and meteoric radiants were identical.

From my observations in 1885 I concluded that the *Lyrids* formed a radiant which, like the *Perseids* of August, moved eastwards amongst the stars from night to night. In 1887 my results supported those of 1885, but indicated a displacement less in extent, though the same in direction. But the evidence of the shifting of the radiant can hardly be regarded as demonstrated, for it is necessary in meteoric work of this kind to proceed with extreme caution, the research being surrounded with difficulties of no ordinary kind. During the present generation the shower of *Lyrids* has been comparatively feeble, and the display has been limited to very few nights, so that it is not feasible to gather a large number of observations, as may be done in the case of the *Perseids*.

Meteors are often singularly rare at this particular season of the year. After making allowance for time spent in registering paths the average horary rate of appearance for one observer, on the nights from April 18 to 22 inclusive, is only 8, including *Lyrids*; but if these are excluded, the rate is reduced to 5. This scarcity of meteors is not confined to this special epoch; it operates generally during the whole of the first half of the year. But though meteors are usually so rare, there is quite a swarm of feeble radiants contemporary with the *Lyrids*, and, selecting a few of the most prominent, they are at

$$202^{\circ} + 9^{\circ}, 213^{\circ} + 53^{\circ}, 217^{\circ} - 9^{\circ}, 218^{\circ} + 33^{\circ}, 228^{\circ} - 2^{\circ}, 231^{\circ} + 17^{\circ}, \\ 252^{\circ} - 21^{\circ}, 263^{\circ} + 62^{\circ}, 272^{\circ} + 21^{\circ}, 296^{\circ} \pm 0^{\circ}, \text{ and } 302^{\circ} + 23^{\circ}.$$

Many others are visible, but the great feebleness of these streams is a bar to their general detection, unless the firmament is watched during the whole night, or, better still, throughout several successive nights. At this season an observer may sometimes watch a beautifully clear, moonless sky for an hour or more.

without noticing a single shooting star, and may be led to suppose, from the stillness of the firmament, that not a single meteoric stream is in play; but if he perseveres in his observations during 15 or 20 hours on a few following nights a considerable number of minor radiants will gradually and accurately manifest themselves in various parts of the heavens.

A summary of my observations of the Lyrids during the epoch from April 16 to 26 1873-98 is given in the following table:—

Date, 1873-98.	Hours of Observation.	Total No. of meteors seen.	Lyrids.	Radiant Point.
April 16	3	14	3	$263^{\circ} + 33^{\circ}$
17	$4\frac{1}{2}$	21	...	...
18	$12\frac{1}{4}$	67	13	$266 + 33$
19	$18\frac{3}{4}$	123	45	$268.6 + 32.3$
20	19	141	62	$272.4 + 32.8$
21	15	88	20	$272.5 + 33.5$
22	$8\frac{1}{2}$	50	6	$275 + 31$
23	4	18	2	
24	1	5	...	
25	$7\frac{1}{4}$	31	...	
26	$4\frac{3}{4}$	19	...	
April 16-26	98	577	151	$271.2 + 32.9$ April 19-21.

The radiants from my own observations are:—

1885 April 18 ...	$260^{\circ} + 33^{\circ}$ *	1879 April 20 ...	$272^{\circ} + 33^{\circ}$
1887 18 ...	$266 + 33$	1885 20 ...	$274 + 33$
1877 19 ...	$269 + 37^{\dagger}$	1887 20 ...	$271 + 33$
1884 19 ...	$269 + 33$	1893 20 ...	$272 + 33$
1885 19 ...	$268 + 33$	1878 21 ...	$272 + 32$
1887 19 ...	$269 + 31$	1893 21 ...	$273 + 34$
1878 20 ...	$273 + 32$	1878 22 ...	$275 + 31$

* Probably Herculids, and representing a stream quite distinct from the Lyrids.

† Certainly 4° N. of correct position. This radiant is omitted in deriving mean place in the previous table, and I have also quite disregarded the centre found at Bristol in 1873-4 when I had not acquired much practical experience in this line of work.

The radiants determined by other observers are :—

1839	Apr. 18	$273^{\circ} + 45^{*}$	58	Herrick.
1845-63	Apr. 19-20	$282 + 33$	25	Greg.
1847-66	Apr. 15-31	$277 + 38$	...	Heis.
1864	Apr. 19-20	$277.5 + 34.6$	23	A. S. Herschel.
1851-68	Apr. 18-29	$277 + 34$	12	Heis.
1867	Apr. 19-20	$278.2 + 34.5$	16	Galle and Karlinski.
1869	Apr. 20	$267 + 35$	7	Serpieri.
1871	Apr. 20	$267 + 35$	17	A. S. Herschel.
1872	Apr. 19	$275 + 32$	17	Lucas.
1874	Apr. 19-21	$268 + 33$	7	Konkoly.
1877-78	Apr. 19-20	$275 + 35$	24	Corder.
1879	Apr. 19	$275 + 37$	13	Corder.
1879	Apr. 19-21	$274 + 34$	10	Sawyer.
1882	Apr. 20	$268 + 37$	26	Corder.
1893	Apr. 20-21	$274.5 + 40.5^{\dagger}$	47	Nijland and Bolt.
1893	Apr. 20-21	$270.5 + 35.5$	25	Corder.
1893	Apr. 20-21	$270 + 33$	...	Ferrington.
1893	Apr. 20-21	$271 + 35.5$	...	Blakeley.
1895	Apr. 19	$274 + 34$	...	Corder.
1895	Apr. 19	$269 + 37$	9	Blakeley.
1895	Apr. 21	$274 + 36$	9	Blakeley.
1896	Apr. 10-22	$275 + 38$	6	A. S. Herschel.
1898	Apr. 21-22	$273 + 33$	12	Besley.
1898	Apr. 12-23	$270 + 40^{\dagger}$	5	A. S. Herschel.
1898	Apr. 20	$275.5 + 31.5$	22	Nijland.
1898	Apr. 21-24	$276 + 34$	16	Nijland.

The mean of the 26 positions is $273^{\circ}.3 + 35^{\circ}.6$.

A large number of valuable observations were made at the epoch of the Lyrids between the years about 1865 and 1874, when the interest in this branch of astronomy had received a great impetus from the discovery of the identity of certain cometary and meteoric orbits. In Austria Professor E. Weiss collected two volumes of observations from 1867 to 1874, and among these were many of the April meteors, though they had never been reduced to their radiant points. The observers were

* Probably 12° N. of the correct position.

† These may represent showers of Draconids, as the radiants are far N. of that of the Lyrids.

Möller, Palisa, Wittek, Schulhof, Oppolzer, Littrow, Strasser, Sauter, Niessl, Holetschek, Karlinski, and others, and the chief places of observation were at Vienna, Kremsmünster, and O-Gyalla.

The Italian Meteoric Association, under the direction of Schiaparelli and Denza, also amassed many thousands of observations in different months, and Zezioli's and Heis's catalogues contain a great many more. The total number of meteors registered by these observers during the special epoch April 16 to 25, in the years from 1865 to 1874, was approximately as follows:—

Weiss's Austrian observations (1867-74)	...	...	1,468	meteors.
Italian Meteoric Association (1869-72)	...	...	997	„
G. Zezioli at Bergamo (1867-70)	...	...	219	„
E. Heis at Münster (1865-74)	...	...	152	„
			2,836	„

I carefully examined all these paths for the purpose of tracing the position of the radiant on succeeding nights, and my results were as follow:—

Date. 1865-74.	Radiant. α δ	Area.	Lyrids.	Meteors observed.
Apr. 16	$270^{\circ} + 31^{\circ}$ *	6	5	35
17	$267 + 29$	6	6	94
18	$268 + 33$	7	7	66
19	$268 + 30$	10	70	294
20	$271 + 34$	15	214	915
21	$273 + 31$	10	79	482
22	$273 + 32$	15	48	396
23	$275 + 33$	7	47	379
24	...	...	2	54
25	$275 + 31$	8	9	121
Apr. 16-25	$271.1 + 31.6$	...	487	2,836

The series of positions greatly favours the idea of a moving radiant, and I think there can be no doubt of its occurrence, though the exact rate of the displacement is not quite certain. Before April 20, both my observations and reductions prove that the radiant is certainly W. of R.A. 270° , while on April 20 and following nights it is as certainly E. of it. I do not, however, attach much importance to radiant points derived from a large

* This position, as well as those for April 17, 18, and 25, are not based upon a sufficient number of paths to be reliable, and little weight should be attached to them.

collection of miscellaneous observations, some of which will be sure to be erroneous, either owing to comparative inexperience on the part of some observers or other causes. On projecting a large number of combined observations of this character upon an 18-inch globe it is usually found that they form very indefinite, scattered radiants extending over areas of 10° , 15° , or even more; and that the centres cannot be assigned with any approach to accuracy. In any doubtful question as to the visible behaviour of meteoric streams, it is not therefore advisable to appeal to such data as capable of affording a final settlement. The selected materials of one observer of known accuracy and experience would be of much greater value, but unfortunately no single individual can furnish the mass of observations desirable. To acquire this, we must necessarily collect materials from many sources; and these, though sufficiently full, are apt to induce doubts as to their accuracy and prove the inexpediency of fully trusting them.

In endeavouring to find whether motion occurs in a radiant, only such meteors should be utilised as are well observed and situated near their radiants. If observers set themselves to accumulate observations of this kind, we should in a few years have the means of disposing of some vexed questions in this branch of observational astronomy. In the case of a shower like the Lyrids, which is very feebly visible except on the night of maximum, it is not likely that photography will render us any efficient help in the immediate future, and so we must continue to look to ordinary eye observation to clear up any doubtful points associated with this system.

I have selected from amongst my observations at Bristol a number of Lyrids which were well seen, and moved chiefly in declination or were near the radiant. Such paths are obviously very important in endeavours to solve the question as to a change of position in the radiant:—

Date.	h m	Mag.	Path.		Length.
			From.	To.	
1884 Apr. 19	11 24	1	$271^\circ + 36^\circ$	$271\frac{3}{4}^\circ + 36\frac{3}{4}^\circ$	0°
1885 Apr. 19	12 19	4	$266 + 37\frac{1}{2}$	$264 + 41$	4
1885 Apr. 19	12 47	3	$274\frac{1}{2} + 39$	$278\frac{1}{2} + 42\frac{1}{2}$	$4\frac{1}{2}$
1887 Apr. 19	12 41	5	$270\frac{1}{2} + 15$	$271\frac{1}{2} + 9$	6
1887 Apr. 19	13 5	3	$270 + 69$	$270\frac{3}{4} + 79\frac{3}{4}$	$10\frac{3}{4}$
1887 Apr. 19	13 13	♀	$269 + 11$	$269 + 1$	10
1895 Apr. 19	11 58	4	$278\frac{1}{2} + 34$	$283\frac{1}{2} + 35\frac{1}{2}$	4
1873 Apr. 20	11 13	2	$264\frac{1}{2} + 16$	$261\frac{1}{2} + 9$	9
1874 Apr. 20	12 35	3	$273 - 5$	$273 - 10$	5
1874 Apr. 20	12 56	2	$270 + 4$	$269 - 3$	7
1878 Apr. 20	9 16	3	$264 + 45$	$260 + 49$	5
1878 Apr. 20	9 30	3	$262 + 36$	$256 + 38$	$5\frac{1}{2}$

Date.	h m	Mag.	Path.		Length.
			From.	To.	
1885 Apr. 20	13 20	4	$275^{\circ}\frac{1}{2} + 27^{\circ}$	$275^{\circ} + 23^{\circ}$	4
1885 Apr. 20	13 46	4	$265 + 53$	$262 + 58$	$5\frac{1}{2}$
1885 Apr. 20	14 12	4	$270 + 12\frac{1}{2}$	$269\frac{1}{2} + 7$	$5\frac{1}{2}$
1885 Apr. 20	14 24	4	$261\frac{1}{2} + 21$	$258 + 16\frac{3}{4}$	6
1885 Apr. 20	14 49	4	$266 + 20\frac{1}{2}$	$263 + 16$	5
1873 Apr. 21	10 22	3	$273 + 51$	$273 + 61$	10
1893 Apr. 21	12 8	4	$270 + 44$	$268 + 49\frac{1}{2}$	6
1893 Apr. 21	12 39	4	$268 + 27\frac{3}{4}$	$266\frac{1}{2} + 25\frac{1}{2}$	$2\frac{1}{2}$
1878 Apr. 22	10 50	5	$265 + 61\frac{1}{2}$	$256 + 71$	11
1894 Apr. 22	9 59	2	$260 + 59$	$243 + 72$	15

Bristol, 1899 February 20.

Nebulæ observed at the Royal Observatory, Cape of Good Hope, in 1898.

(Communicated by David Gill, C.B., F.R.S., &c., H.M. Astronomer.)

The following observations were made by Mr. R. T. A. Innes with the 7-inch Merz equatorial :—

No.	1860.			Dec.	
	R.A.	h	m s		
1	3 27 44	—52	23		Equal to 10 ^m ·5, round, 2' diameter, near C.P.D.—52°, 414.
2	4 4 41	—45	53		Equal to 9 ^m ·8, round, 10'' diameter, near C.P.D.—45°, 403.
3	4 14 8	—60	33		Equal to 9 ^m ·8, round, 1' diameter, brighter in middle.
4	5 39 0	—51	6		Equal to 9 ^m ·7, round, 10'' diameter, brighter in middle.
5	14 12 5	—59	56		Faint, small, elongated.

The above are supposed to be new.

h 2629=G. C. 834 The position for 1860 is about 4^h 12^m 44^s —55° 56', the place in the N.G.C. being wrong. It is quite close to C.Z. IV., 419, mag. 8·5, reddish, and is 13' N. *p*.

h 2630=G.C. 838, which is a double nebula, the smaller component being N. *f*.

h 3443. *h* calls this a cluster. It now looks like an irregular nebula surrounding two stars.

H. V. 39. Not seen; H. V. 40, which is near, and has exactly the same description, was well seen.

Royal Observatory, Cape of Good Hope:
1899 January 6.

Occultations Observed at the Royal Observatory, Cape of Good Hope, during the Lunar Eclipse, 1898 December 27.

(Communicated by David Gill, C.B., F.R.S., &c., H.M. Astronomer.)

A list of predictions was received from the Pulkowa Observatory. The observers, instruments, and their positions referred to the Cape Transit Circle, were :—

Observer.	Instrument.	δ Long.	δ Lat.	Alt.
H = S. S. Hough	7-in. Heliometer	$-0^{\circ}05^s$	$+2^{\circ}01'$	} About 40 ft.
L = J. Lunt	18-in. McClean Refractor	$+0^{\circ}03$	$-3^{\circ}43'$	
I = R. T. A. Innes	7-in. equatorial	$+1^{\circ}12'$	$-2^{\circ}02'$	
V L = V. A. Löwinger	10-in. astrographic guiding telescope	$-1^{\circ}10'$	$+4^{\circ}42'$	

Position of T.C.

Long. $-1^h 13^m 54^s.76$

δ Long. $- =$ E. of T.C.

Lat. $-33^{\circ} 56' 3''.5$

δ Lat. $- =$ S. of T.C.

The definition became very bad towards the end of the eclipse.

All the observers remark that the stars at disappearance seemed to enter on the Moon's disc.

Observations.

No.	Pulkowa List.	Name.	Mag.	Obsr.	Inst.	Phase.	Cape Sid. Time.			Greenwich M.T.			Remarks.
							h	m	s	h	m	s	
1	—	Anon = B.D. + 24°, 1298 + 30° ±	9.7	L.	18-in.	D.	6	23	46.2	10	44	7.6	
2	33	B.D. + 24°, 1300	9.4	"	"	"	6	33	8.7	10	53	28.6	
"	"			I.	7	"	6	33	8.7	10	53	28.6	Very good.
"	"			V.L.	10	"	6	33	8.7	10	53	28.6	Faint.
3	25	B.D. + 24°, 1296	9.4	L.	18	R.	7	0	15.9	11	20	31.3	
"	"			V.L.	10	"	7	0	16.2	11	20	31.6	Good.
4	37	Arg. + 24°, 1303	9.1	L.	18	D.	7	1	47.7	11	22	2.9	
"	"			I.	7	"	7	1	47.7	11	22	2.9	Very good.
"	"			V.L.	10	"	7	[2]	48.9	11	22	4.1	Uncertain.
5	44	B.D. + 24°, 1306	9.2	L.	18	"	7	10	41.7	11	30	55.4	
"	"			I.	7	"	7	10	41.2	11	30	54.9	Good.
"	"			V.L.	10	"	7	10	40.9	11	30	54.6	Very fair.
6	—	Anon = B.D. + 24°, 1303 + 13° - 0'.8	9.5	I.	7	"	7	10	49.7	11	31	3.4	Fair.

No.	Pulkowa List.	Name.	Mag.	Obsr.	Inst.	Phase.	Cape Sid.			Greenwich M.T.			Remarks.
							h	m	s	h	m	s	
7	42	B.D. + 24°, 1305	9.2			H. Heliom.	7	16	36.0	11	36	48.8	Good.
"	"					L. 18-in.	7	16	36.9	11	36	49.7	
"	"					I. 7	7	16	37.3	11	36	50.1	Very good.
"	"					V.L. 10	7	16	36.9	11	36	49.7	Good.
8	—	B.D. + 24°, 1311	9.4			L. 18	7	25	55.7	11	46	6.9	Bad definition.
9	49	Arg. + 24°, 1310	9.2	"	"	"	7	26	53.2	11	47	4.3	
10	48	B.D. + 24°, 1309	9.0			H. Heliom.	7	30	35.5	11	50	46.0	Very good.
"	"					L. 18-in.	7	30	35.4	11	50	45.9	
"	"					I. 7	7	30	35.4	11	50	45.9	Very good.
"	"					V.L. 10	7	30	35.5	11	50	46.0	Good.
11	47	B.D. + 24°, 1308	9.3			I. 7	7	31	58	11	52	8	Worthless.
"	"					V.L. 10	7	31	58.7	11	52	8.9	Fair, faint.
12	56	B.D. + 24°, 1313	9.2			L. 18	7	53	40.7	12	13	47.4	
"	"					I. 7	7	53	42	12	13	48	Worthless.
"	"					V.L. 10	7	53	41.2	12	13	47.9	Bad.

Royal Observatory, Cape of Good Hope:
1899 January 6.

*On the Use of the Electric Light for the Artificial Star of a
Zöllner Photometer. By W. de Sitter.*

(Communicated by David Gill, C.B., &c., H.M. Astronomer at the Cape.)

During the last few months I have been engaged on photometric work in connection with an investigation of the systematic difference between visual and photographic magnitudes of stars in the Milky Way and near its poles.

The instrument used is the 6-inch equatorial, by Grubb, belonging to the Cape Observatory, to which an ordinary Zöllner photometer has been adapted in the way recommended by Zöllner (*Photometrische Untersuchungen*, Plates V. and VI.). As is fully explained in Zöllner's work, the paraffin lamp was automatically kept in a horizontal position while the telescope was being driven by the clockwork. On nights without wind the lamp performed very satisfactorily, and remained practically constant throughout the time of observation—usually from $1\frac{1}{2}$ to 2 hours. But there are very few nights without wind at the Cape; and when the south-easter was blowing with its usual velocity of between 15 and 30 miles an hour, it was absolutely impossible to observe. This induced me to try to

replace the oil lamp by an electric lamp, the light of which would not be affected by the wind. As this is, so far as I know, the first trial ever made of the use of electric light in stellar photometry, I have thought it not without interest to publish my first experiences. Professor Müller writes (*Photometrie der Gestirne*, p. 252): "Eine grosse Gefahr ist das durch Wind und Luftzug hervorbrachte Flackern der Flamme, welches namentlich das Beobachten im Freien wesentlich erschwert. Man kann sich zwar durch zweckmässige Construction der Blechcylinder, wie es bei den Potsdamer Photometern geschehen ist, theilweise dagegen schützen, es würde aber eine wesentliche Verbesserung des Apparates erzielt werden können, wenn es gelänge, anstatt der Petroleum-Lampe das elektrische Licht nutzbar zu machen . . . , und es kann nicht dringend genug zu Versuchen in dieser Richtung aufgefordert werden."

At first I simply put a 4-volt lamp in place of the oil lamp. The arrangement was then as follows:—The electric lamp was fixed to the brass bar which before carried the oil lamp, and was so adjusted that the light of a portion of the glowing filament fell through the small pinhole at the end of the photometer tube. The light after traversing the tube in the direction of its optical axis, and after passing through the various Nicol prisms, was reflected at an angle of 45° to form an image in the focus of the eyepiece. This image was a very sharp one, and more constant, as well as more star-like, than that formed by the oil lamp; and the equality of brightness of the real and artificial stars could be established quicker and with greater certainty than before.

But I found at the same time that the optical axis of the instrument did not coincide with its axis of rotation, and no adjustment could bring it to coincidence. In fact, there is no definite "axis of rotation." The rotating part of the instrument is not a circle resting on pivots, but a tube rotating inside another tube, and the mechanical fit is not so perfect (and, indeed, cannot be expected to be so in an instrument of this size and quality) as not to allow a certain irregular amount of play in the direction of the instantaneous axis of rotation. With the oil lamp, where a portion of a broad and practically uniformly illuminated surface is used, this introduced no appreciable error, but with the electric lamp the consequence was that in different positions of the rotating tube a different part, or a part of different size, of the glowing filament was used, so that the observations were not strictly comparable.

This error would perhaps be eliminated to a great extent by observing in the four quadrants; but a far better idea was suggested by Dr. Gill, viz. to have the lamp fixed to the end of the tube, so that it would rotate with it, and the relative positions of lamp, pinhole, and optical parts of the instrument would remain unchanged while the tube was rotated on its axis. This plan has been executed, and gives very good results.

To the end of the tube is clamped a piece of ebonite, in which a $3\frac{1}{2}$ -volt lamp is fixed in an adjustable manner. The current is supplied from two accumulator cells in series, placed in the basement of the Observatory, and completely charged twice a week. These cells have a capacity of 130 ampère-hours, and yield a current having a practically constant E.M.F. of 4 volts.

From the cells the current is brought to the top of the pillar, and thence through free-hanging flexible wires to the lamp, so that there is nowhere any spring contact, which might introduce a difference of resistance in different positions of the instrument. No other lamps are fed from the same cells, and I find that the light is not only absolutely constant throughout the observations of one night, but generally even from night to night. A resistance coil has been introduced into the circuit, which enables me to regulate the brightness of the artificial star so as to avoid very small readings, for which the accuracy is not so great as between 10° and 50° . I can now make accurate observations of stars from the 1st to the 11th magnitude.

The weather has been extraordinarily bad this season, so that I had no time to make special observations for the purposes of this paper, and those now quoted simply form part of my regular observations. I observed every star in the four quadrants. The circle is divided from 0° to 180° in two directions, the reading 90° corresponding to the maximum brightness, and 0° and 180° to entire extinction. If there were no index error, and no systematic errors in the instrument, and no errors of observation, the readings in the four quadrants would be :—

$$\phi, 180^\circ - \phi, 180^\circ - \phi, \phi.$$

In reality the four readings are :—

$$\phi_1, 180^\circ - \phi_2, 180^\circ - \phi_3, \phi_4.$$

If we take the means of the readings in two adjacent quadrants, such as

$$\begin{aligned} \phi_{1+2} &= \frac{1}{2}(\phi_1 + \phi_2) & \phi_{1+4} &= \frac{1}{2}(\phi_1 + \phi_4) \\ \phi_{3+1} &= \frac{1}{2}(\phi_3 + \phi_4) & \phi_{2+3} &= \frac{1}{2}(\phi_2 + \phi_3), \end{aligned}$$

the index error will be eliminated from these means. Now it is easy to see that any systematic error depending on the position of the rotating tube will have opposite effects on ϕ_{1+2} and ϕ_{3+4} , and also on ϕ_{1+4} and ϕ_{2+3} .

I therefore tabulated the differences $\phi_{1+2} - \phi_{3+4}$ and $\phi_{1+4} - \phi_{2+3}$ for a number of observations made on different nights in November and December of last year. The third and fourth columns of the following table give these differences, arranged in order of magnitude, of the mean of the four readings :—

Wt. Nr.	ϕ_0	$\phi_{1.2}-\phi_{3.4}$	$\phi_{1.4}-\phi_{2.3}$	Δ_1 m	Δ_2 m	Wt. Nr.	ϕ_0	$\phi_{1.2}-\phi_{3.4}$	$\phi_{1.4}-\phi_{2.3}$	Δ_1 m	Δ_2 m
1	8.4	-0.3	+1.2	-0.4	+1.6	32	22.8	-4.9	+1.2	-2.2	+0.5
2	8.5	+1.0	-0.6	+1.3	-0.8	33	23.0	+0.6	+1.7	+0.3	+0.7
3	8.8	+1.5	+1.0	+1.9	+1.2	34	23.0	+2.0	-1.6	+0.9	-0.7
4	9.9	-0.5	+1.0	-0.6	+1.1	35	23.0	+2.0	+2.0	+0.9	+0.9
5	10.5	+0.6	+0.6	+0.6	+0.6	36	23.9	+2.2	+1.8	+1.0	+0.8
6	10.7	+1.0	+1.0	+1.0	+1.0	37	24.8	+2.5	+3.5	+1.0	+1.4
7	11.8	+0.5	-1.5	+0.5	-1.4	38	24.9	+0.9	+4.9	+0.4	+2.0
8	12.2	-0.5	-1.0	-0.4	-0.9	39	26.8	+6.5	0	+2.6	0
9	13.2	-2.0	+0.5	-1.6	+0.4	40	29.8	-0.3	-0.4	-0.1	-0.1
10	15.8	+0.5	-0.5	+0.3	-0.3	41	30.4	+0.8	+2.3	+0.3	+0.8
11	15.8	-1.5	-0.5	-1.0	-0.3	42	30.5	-3.0	+4.0	-1.0	+1.3
12	15.8	+0.7	-1.3	+0.5	-0.8	43	33.4	-0.3	-2.3	-0.1	-0.7
13	17.1	-1.3	+1.3	-0.8	+0.8	44	34.1	+2.2	-0.2	+0.7	-0.1
14	18.0	+4.0	+1.0	+2.4	+0.6	45	34.8	-2.0	+2.0	-0.5	+0.5
15	18.2	+1.5	+1.5	+0.9	+0.9	46	36.0	+1.0	-0.4	+0.2	-0.1
16	18.2	+2.0	+4.5	+1.2	+2.7	47	41.4	-3.2	+4.7	-0.6	+0.9
17	18.5	+0.6	+1.0	+0.4	+0.6	48	42.5	+3.0	-1.0	+0.6	-0.2
18	18.6	+2.3	-0.3	+1.4	-0.2	49	48.0	+1.0	-2.0	+0.2	-0.4
19	19.0	-0.4	+2.0	-0.2	+1.2	50	50.8	-1.0	+6.8	-0.2	+1.0
20	19.2	+3.7	+1.6	+1.9	+0.8	51	53.5	+1.0	0	+0.2	0
21	19.9	-1.8	+2.7	-0.9	+1.4	52	56.6	+2.8	+2.0	+0.4	+0.3
22	20.0	-1.0	+1.0	-0.5	+0.5	53	56.8	-1.5	-1.5	0.2	-0.2
23	20.9	+0.7	-1.3	+0.3	-0.6	54	57.0	0	+3.0	0	+0.4
24	20.9	-0.3	-0.4	-0.2	-0.2	55	58.2	+0.5	-0.5	+0.1	-0.1
25	21.3	+3.4	-3.5	+1.6	-1.7	56	58.8	-9.5	-3.5	-1.1	-0.4
26	21.6	+1.7	+0.5	+0.8	+0.2	57	70.2	-2.5	+1.5	-0.1	+0.1
27	22.0	+0.4	-3.0	+0.2	-1.3	58	70.6	-3.2	+4.3	-0.2	+0.2
28	22.5	-3.0	-2.6	-1.3	-1.1	59	76.8	+6.5	+0.5	+0.3	+0.2
29	22.6	+0.8	+1.2	+0.4	+0.5	60	82.0	+3.0	-3.0	+0.1	-0.1
30	22.6	+0.4	+0.8	+0.2	+0.4	61	82.4	-6.8	+6.7	-0.3	+0.3
31	22.7	+1.0	0	+0.4	0						

The residuals $\phi_{1.2}-\phi_{3.4}$ and $\phi_{1.4}-\phi_{2.3}$ are very small, and it will be seen from the table that there is no regularity in the distribution of the positive and negative signs. We may safely conclude that *there is no appreciable systematic error in the instrument*, and that therefore the residuals are due to pure accidental errors of observation. On that supposition the difference $\phi_{1.2}-\phi_{3.4} = \frac{1}{2}(\epsilon_1 + \epsilon_2) - \frac{1}{2}(\epsilon_3 + \epsilon_4)$, where ϵ_1 is the error of ϕ_1 , &c. These differences are therefore equivalent to errors of observation of one single pointing, or to twice the error of the mean of four pointings. Accordingly in the fifth and sixth columns I have given the numbers of the third and fourth columns divided by two and converted into magnitudes. Treating these as the residuals in the method of least squares, we find for the probable error of one observation, consisting of four pointings,

$$\pm 0^m.061.$$

The results given in this paper must only be considered as of a preliminary character. I intend to make a more thorough investigation of the instrument as soon as I can do so without seriously interfering with my regular observations.

*Royal Observatory, Cape of Good Hope :
1899 January 3.*

The Greenwich Meridian Observations of Polaris, 1836-1893, with reference to Personality, the value of the Constant of Aberration, and the Star's parallax. By W. G. Thackeray.

Some years ago, when discussing the observations of *Polaris* with the view of obtaining a value of the nutation constant, the results were likewise arranged with the purpose of determining the annual errors, but it was afterwards found that to include the two discussions in one paper made it too cumbersome, and so the latter part was omitted and the papers have lain dormant since. In turning out some old papers I have lately come upon them, and I append this short preface as an explanation why the right ascensions are reduced in the present form, and how it is that reference is made below to personal equations.

The right ascensions here dealt with are those extending from 1836 to 1893, and are divided into two periods. The first includes the observations made with the transit instrument from 1836 to 1850, and the second those made with the transit circle from 1851 to 1893. They have been all reduced to the year 1890.0 with the Struve-Peters value of precession, with the adopted value of the proper motion for 1890 of $+0^s.1550$, the value which was obtained from the discussion on the constant of nutation (*Mem. R.A.S.* vol. li.). They have further been corrected for personal equation to the adopted standard observer "C" by the quantities given in Table III. on p. 252 of the paper referred to above, a process which involved a considerable amount of work, and of which it seems desirable to preserve a record.

The values for any monthly mean are the combination of the results above and below pole, weighted according to the number of observations, and are given uncorrected for personality as well as corrected for personality.

The observations in January and February are mostly below-pole observations, those in July and August above-pole observations, but no observation is kept for place unless the azimuth error has been determined from the consecutive transits of one of the close circumpolars.

The observations have been taken direct from the "Greenwich Observations," and those for 1836-1850 have been corrected further to reduce them to the value of the aberration constant 20.445 .

Monthly Means of Right Ascensions of Polaris reduced to 1890. (Adopted P.M. + 0^h 15^m 50^s for 1890.)

I.—1836–1850. Transit Instrument. Uncorrected for Personality.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
α'	$33^{\circ}22'_{70}$	$33^{\circ}09'_{22}$	$33^{\circ}02'_{44}$	$32^{\circ}31'_{167}$	$31^{\circ}88'_{185}$	$31^{\circ}49'_{131}$	$30^{\circ}80'_{30}$	$30^{\circ}44'_{78}$	$30^{\circ}24'_{130}$	$32^{\circ}30'_{110}$	$32^{\circ}51'_{137}$	$32^{\circ}54'_{183}$
α	$31^{\circ}91$	...	...	...	...	...	...	...	...	...	...	...
$\alpha' - \alpha$	$+ 1^{\circ}31$	$+ 1^{\circ}18$	$+ 1^{\circ}71$	$+ 0^{\circ}40$	$- 0^{\circ}03$	$- 0^{\circ}42$	$- 1^{\circ}11$	$- 1^{\circ}47$	$- 1^{\circ}67$	$+ 0^{\circ}39$	$+ 0^{\circ}60$	$+ 0^{\circ}63$

II.—1836–1850. Transit Instrument. Corrected for Personality.

α'	$32^{\circ}27$	$32^{\circ}13$	$32^{\circ}72$	$31^{\circ}56$	$30^{\circ}95$	$30^{\circ}80$	$30^{\circ}04$	$29^{\circ}89$	$29^{\circ}59$	$31^{\circ}47$	$31^{\circ}64$	$31^{\circ}76$
α	$31^{\circ}13$	...	...	...	...	...	...	...	...	...	...	...
$\alpha' - \alpha$	$+ 1^{\circ}14$	$+ 1^{\circ}00$	$+ 1^{\circ}59$	$+ 0^{\circ}43$	$- 0^{\circ}18$	$- 0^{\circ}33$	$- 1^{\circ}09$	$- 1^{\circ}24$	$- 1^{\circ}54$	$+ 0^{\circ}34$	$+ 0^{\circ}51$	$+ 0^{\circ}63$

III.—1851–1893. Transit Circle. Uncorrected for Personality.

α'	$31^{\circ}09'_{125}$	$31^{\circ}82'_{92}$	$31^{\circ}45'_{338}$	$31^{\circ}20'_{105}$	$30^{\circ}66'_{317}$	$30^{\circ}74'_{338}$	$30^{\circ}97'_{333}$	$31^{\circ}18'_{104}$	$30^{\circ}72'_{179}$	$31^{\circ}07'_{169}$	$31^{\circ}24'_{399}$	$31^{\circ}51'_{216}$
α	$31^{\circ}10$	...	...	...	...	...	...	...	...	...	...	...
$\alpha' - \alpha$	$+ 0^{\circ}80$	$+ 0^{\circ}72$	$+ 0^{\circ}35$	$+ 0^{\circ}10$	$- 0^{\circ}44$	$- 0^{\circ}36$	$- 0^{\circ}13$	$+ 0^{\circ}08$	$- 0^{\circ}38$	$- 0^{\circ}03$	$+ 0^{\circ}14$	$+ 0^{\circ}41$

IV.—1851–1893. Transit Circle. Corrected for Personality.

α'	$31^{\circ}44$	$31^{\circ}66$	$31^{\circ}59$	$31^{\circ}35$	$30^{\circ}97$	$30^{\circ}81$	$31^{\circ}04$	$31^{\circ}01$	$30^{\circ}46$	$31^{\circ}15$	$31^{\circ}32$	$31^{\circ}66$
α	$31^{\circ}14$	...	...	...	...	...	...	...	...	...	...	...
$\alpha' - \alpha$	$+ 0^{\circ}30$	$+ 0^{\circ}52$	$+ 0^{\circ}45$	$+ 0^{\circ}21$	$- 0^{\circ}17$	$- 0^{\circ}33$	$- 0^{\circ}10$	$- 0^{\circ}13$	$- 0^{\circ}68$	$+ 0^{\circ}01$	$+ 0^{\circ}18$	$+ 0^{\circ}52$

Comparing the results deduced with and without a correction for personality, it is apparent that such a correction is not justified by the little smoothing that is made, and seems to show that at Greenwich, where there are many observers engaged in observing, personality works little or no harm in the course of a year.

It is also clear that the results obtained with the transit circle are very superior to those obtained with the transit instrument. Therefore the transit-circle results alone are used in the rest of this paper, and those uncorrected for personality (III.).

Now let K be the correction to the adopted constant of aberration $20''.445$, and let P be the star's parallax, a' the apparent and a the mean R.A. ; then we have (Chauvenet, vol. i. pp. 633 and 645) :—

$$\begin{aligned} a' - a &= -K \sec \delta (\cos \odot \cos \epsilon \cos \alpha + \sin \odot \sin \alpha) \\ &\quad - P \sec \delta (\cos \odot \sin \alpha - \sin \odot \cos \epsilon \cos \alpha). \end{aligned}$$

Then, assuming that no appreciable error will be introduced by taking the value of the Sun's longitude for the middle of each month—or, in other words, that the monthly means correspond fairly to the mean date of the month—and giving a weight of 1 to every hundred observations, we get the following series of equations :—

Right Ascensions.			
		^s	W.
- 3.1 K	- 41.5 P	= + 0.80	1
- 24.4	- 33.8	= + 0.72	1
- 37.2	- 18.5	= + 0.35	3
- 41.4	+ 3.0	= + 0.10	5
- 34.8	+ 22.8	= - 0.44	3
- 18.8	+ 37.0	= - 0.36	3
+ 1.2	+ 41.6	= - 0.13	1
+ 21.6	+ 35.5	= + 0.08	1
+ 36.5	+ 19.9	= - 0.38	5
+ 41.5	- 0.8	= - 0.03	5
+ 35.3	- 21.9	= + 0.14	4
+ 19.2	- 36.8	= + 0.41	2

$$\begin{aligned} 39179 K - 2295 P &= - 47.31^s \\ - 2295 K + 19685 P &= - 224.91^s \end{aligned}$$

whence

$$\begin{aligned} P &= - 0.012^s \\ K &= - 0.002^s \end{aligned}$$

which give

Aberration.	Parallax.
$20''.42$	$- 0''.17$

The value of the parallax from the right ascensions is thus negative, showing that the observations are affected by some other annual term.

We now come to the declinations.

The observations are those made with the transit circle from 1851 to 1893, and thus comprise six complete periods of Chandler's latitude variation. The observations are all reduced on one system, that in present use, and have been corrected for the newly determined values of division errors, which are, generally speaking, for *Polaris* 1851-1877 ''00, and for 1878-1893 + 0''.25, *Polaris* S.P. 1851-1856 + 0''.10, 1857-1877 - 0''.10, and for 1878-1893 ''00. The observations from 1868 to 1876 have also been corrected for the wear in the microscope micrometer screws. The observations are all reduced to 1890 with an adopted proper motion of - 0''.005.

Monthly Means of Declinations of Polaris 1851-1893 reduced to 1890. (Adopted P.M. - 0''.005.)

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
$\delta' =$	18° 6' 53.12	18° 45' 25.3	18° 26' 43.7	18° 09' 53.3	18° 15' 7.27	18° 25' 60.3	18° 68' 88.5	18° 79' 33.8	18° 63' 3.34	18° 54' 62.3	18° 49' 380	18° 57' 47.1
$\delta =$	18° 42'	...	...	...	...	...	...	...	...	...	...	...
	+ 0.23	+ 0.03	- 0.16	- 0.33	- 0.27	- 0.17	+ 0.26	+ 0.37	+ 0.21	+ 0.12	+ 0.07	+ 0.15

Let K be the correction to the adopted constant of aberration, P the star's parallax, δ' and δ the apparent and mean declination, then by Chauvenet, vol. i. p. 633,

$$\delta' - \delta = -K \cos \odot (\sin \epsilon \cos \delta - \cos \epsilon \sin \delta \sin \alpha) - K \sin \odot \sin \delta \cos \alpha - P \sin \odot (\cos \epsilon \sin \delta \sin \alpha - \sin \epsilon \cos \delta) - P \cos \odot \sin \delta \cos \alpha.$$

Then, assuming the value of the Sun's longitude as before, we get the following series of equations :—

<i>Declinations.</i>			W.	C—O	+ $''_{17} \sin 2\odot$
+1°00 K	—0°13 P	= +0°23	3	—0°22	—0°13
+0°77	—0°63	= +0°02	3	—0°14	—0°16
+0°38	—0°91	= —0°19	5	°00	—0°03
—0°13	—0°98	= —0°31	7	+0°07	+0°13
—0°60	—0°79	= —0°27	7	+0°07	+0°16
—0°91	—0°37	= —0°17	6	+0°05	+0°03
—0°98	+0°09	= +0°26	4	—0°28	—0°12
—0°81	+0°57	= +0°37	4	—0°27	—0°16
—0°42	+0°90	= +0°21	5	—0°02	—0°04
+0°08	+0°99	= +0°11	6	+0°13	+0°12
+0°57	+0°81	= +0°07	6	+0°13	+0°16
+0°90	+0°40	= +0°15	5	—0°07	+0°04

$$23.69 K + 3.56 P = +1.71$$

$$+3.56 K + 34.44 P = +8.13,$$

whence

$$P = +0.23$$

$$K = +0.037,$$

which give

$$\begin{array}{l} \text{Aberration.} \\ 20''.49 \end{array}$$

$$\begin{array}{l} \text{Parallax.} \\ +0''.23. \end{array}$$

The residuals C—O appear to demonstrate the existence of a six months' term, which can be fairly expressed by the formula $+''_{17} \sin 2\odot$, and which appears to be consistent and persistent throughout the period, for it is found that the values of the coefficient for the two periods 1851–1868 and 1869–1893 are $+''_{13}$ and $+''_{24}$ respectively. It will, however, be found that it does not affect the determined values of either the aberration or the parallax. In order to trace, if possible, the origin of this period the observations above and below pole have been separated, and the results given by Polaris and Polaris S.P. have both been discussed for the values of the aberration constant and for parallax. It will be seen that the aberration constant now differs considerably for the two determinations, the value from the above pole observations being the larger.

Monthly variations in declination of Polaris and Polaris S.P., 1851-1893.

	Polaris,			Polaris S.P.			C-O	
	$\delta' - \delta$	No. of Obs.	Wt.	$\delta' - \delta$	No. of Obs.	Wt.	Polaris.	Polaris S.P.
January	+ 0"28	278	5	+ 0"17	64	1	- 0"27	- 0"16
February	+ 0'02	184	3	- 0'07	69	1	- 0'14	- 0'05
March	- 0'17	232	4	- 0'28	235	4	- 0'04	+ 0'07
April	- 0'49	247	4	- 0'20	435	7	+ 0'23	- 0'06
May	- 0'27	238	4	- 0'32	489	8	+ 0'04	+ 0'09
June	- 0'32	203	3	- 0'13	400	7	+ 0'19	'00
July	- 0'01	111	2	+ 0'35	274	5	- 0'01	- 0'37
August	'00	94	2	+ 0'53	264	4	+ 0'11	- 0'42
September	+ 0'01	300	5	+ 0'39	236	4	+ 0'20	- 0'18
October	+ 0'14	362	5	+ 0'17	267	4	+ 0'11	+ 0'08
November	+ 0'19	343	6	+ 0'05	237	4	+ 0'04	+ 0'18
December	+ 0'35	308	5	- 0'13	163	3	- 0'21	+ 0'27
Mean δ	18'47	2900	...	18'41	3125			

Equating as before, we get ;—

	Aberration.	Parallax.
Polaris	20'67	+ 0"21
Polaris S.P.	20'30	+ 0'30
Mean	20'49	+ 0'26

The values of C-O in the table above are given for the mean values of the aberration and parallax. An inspection will show that the six months' term has apparently disappeared, and that the residuals for Polaris S.P. are large.

In the course of a year the observations of Polaris and Polaris S.P. between them are fairly distributed throughout the day and night, as will be seen from the following diagram, where the dark line represents the time when the observations are made between sunset and sunrise, and the absence of the line the time when they are made between sunrise and sunset :—

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Polaris												
Polaris S.P.												

Rearranging the observations of Polaris and Polaris S.P. indiscriminately to represent daylight and night observations in

accordance with this diagram, and giving each month the same weights as above, we get :—

	Aberration.	Parallax.
Daylight	20 ^{''} 65	+ 0 ^{''} 21
Night	20 ^{''} 36	+ 0 ^{''} 34

It must be borne in mind that the observations of Polaris are peculiarly liable to anything like diurnal periods in the zenith-point corrections.

Note on Diurnal Variations of the nadir and level of the Transit Circle at the Royal Observatory, Greenwich.

(Communicated by the Astronomer Royal.)

Suspicion having been aroused as to the possibility of a variation in nadir of the transit circle depending on the hour of the day, observations of the nadir and level have been made at Greenwich three times a day on all fine days since the middle of 1895—once in the early part of the day, again as soon as observations were commenced in the evening, and finally at the end of the evening's work. These observations have been here arranged in three groups, each extending to six hours, viz. 21^h—3^h, 3^h—9^h, 9^h—15^h (astronomical reckoning), representing roughly the observations made about midday, about sunset, and at the end of the evening's work. Taking the results of the middle group 3^h—9^h as zero, the following table exhibits for each month the corrections to this group (that is, to the nadir observation made about sunset) derived from the observations made about midday and midnight :—

DIURNAL VARIATIONS OF THE NADIR.

Corrections to the observations of the nadir about 6 P.M. deduced from the observations made about midday and midnight.

Month.	1895.		1896.		1897.		1898.		Means.		No. of Obs.
	21 ^h to 3 ^h .	9 ^h to 15 ^h .	21 ^h to 3 ^h .	9 ^h to 15 ^h .	21 ^h to 3 ^h .	9 ^h to 15 ^h .	21 ^h to 3 ^h .	9 ^h to 15 ^h .	21 ^h to 3 ^h .	9 ^h to 15 ^h .	
Jan.	...	...	...	...	...	...	...	...	...	...	20
Feb.	...	...	...	...	...	...	...	...	...	...	28
Mar.	...	...	...	...	...	...	...	...	...	...	36
Apr.	...	...	...	...	...	...	...	...	...	...	56
May	...	...	...	...	...	...	...	...	...	...	58
June	...	...	...	...	...	...	...	...	...	...	54
July	...	...	...	...	...	...	...	...	...	...	74
Aug.	...	...	...	...	...	...	...	...	...	...	102
Sept.	...	...	...	...	...	...	...	...	...	...	82
Oct.	...	...	...	...	...	...	...	...	...	...	80
Nov.	...	...	...	...	...	...	...	...	...	...	56
Dec.	...	...	...	...	...	...	...	...	...	...	54
Means	...	...	...	...	...	...	...	...	...	...	700

An inspection of this table will show that there appears to be a semi-diurnal variation in the nadir, whose amplitude varies in the different months. The groups into which the observations are divided are too long to give very reliable details, but the observations are not sufficiently numerous to warrant smaller subdivisions.

As it is manifestly of interest to see if the observations of level show any similar variations, the level errors have been collected together for those days on which three observations have been made within the times specified, by the arrangement of groups referred to above, and they are here given in an exactly similar form to those of the nadir:—

DIURNAL VARIATIONS OF THE LEVEL ERROR.													
<i>Corrections to the values of the level error found about 6 P.M. from the observations made about midday and midnight.</i>													
Month.	1895.			1896.			1897.			1898.			No of Obs.
	21 ^h to 3 ^h .	9 ^h to 15 ^h .	"	21 ^h to 3 ^h .	9 ^h to 15 ^h .	"	21 ^h to 3 ^h .	9 ^h to 15 ^h .	"	21 ^h to 3 ^h .	9 ^h to 15 ^h .	"	General Mean.
Jan.	...	...	...	...	...	...	...	...	...	...	...	...	20
Feb.	...	...	...	...	...	...	...	...	...	...	...	...	30
Mar.	...	...	...	...	...	...	...	...	...	...	...	...	46
Apr.	...	...	...	...	...	...	...	...	...	...	...	...	58
May	...	...	...	...	...	...	...	...	...	...	...	...	60
June	...	...	...	...	...	...	...	...	...	...	...	...	50
July	...	...	...	...	...	...	...	...	...	...	...	...	68
Aug.	...	...	...	...	...	...	...	...	...	...	...	...	100
Sept.	...	...	...	...	...	...	...	...	...	...	...	...	88
Oct.	...	...	...	...	...	...	...	...	...	...	...	...	84
Nov.	...	...	...	...	...	...	...	...	...	...	...	...	50
Dec.	...	...	...	...	...	...	...	...	...	...	...	...	48
Means	...	...	...	...	...	...	...	...	...	...	...	...	762

This table shows that there is a semi-diurnal variation in the level as well as in the nadir. It would follow from this that stars 6^h apart in right ascension would be liable to give the value of the azimuth error systematically different.

Photographs of Comets, and of the Milky Way. By E. E. Barnard.

I have, at various times, sent a number of photographs of the Milky Way, comets, &c., &c., to the Royal Astronomical Society, but these were not accompanied by any descriptions of the pictures.

It was my intention to describe in detail each one of these pictures to facilitate their study, and to put on record some of the more important features shown on the plates; for various reasons I was unable to do this when sending the pictures. I take the opportunity now, while sending a number of lantern slides from these and other pictures, to partially remedy the omission.

The Royal Astronomical Society has published some reproductions and lantern slides from the star and comet pictures previously sent. The present descriptions will also cover some of these, and for easy reference I shall indicate such pictures by the additional designation, *R.A.S.*, No. —, the number being that given in the "List of Reproductions of Celestial Photographs published by the Royal Astronomical Society" (see page 210). At best, these descriptions will cover only a few of the total lot of pictures sent by me to the R.A.S. at various times.

A few brief remarks of an historical nature may perhaps be important before entering on the descriptions.

While connected with the Lick Observatory, a series of photographs was made of all the different portions of the Milky Way which were visible from that latitude. This work was begun in the spring of 1889. The instrument employed, as is well known, was a 6-inch portrait lens of 31 inches focus, which bore the name of Willard, and the date 1859, and for this reason I have called it the "Willard lens" in all my work. This lens was used in the early days of wet plate photography for portrait work in a San Francisco photograph gallery. In the early times it was necessary to use a large aperture to lessen the duration of exposure in taking portraits; but after the invention of the quick dry plates, such a large lens became unnecessary, and this one was discarded for smaller and more convenient lenses.

Upon experimenting with this large lens, I found, on account of its wide field and great light-grasping power, that it was specially suited for the photography of the Milky Way, comets, &c. It was attached to a wooden camera box, and was first used by strapping it to the tube of the 6-inch equatorial. Latterly it was placed on an ordinary equatorial mounting, which did not permit continuous exposures to be carried across the meridian.

Besides the pictures of the Milky Way and nebulae, a number of photographs were secured of Swift's Comet of 1892, Holmes's

Comet of 1892, Brooks's Comet of 1893, and Gale's Comet of 1894.

The photographs of the Milky Way made with the Willard lens were the first to show its cloud forms and general structure. They opened up the means for a thorough study of the Milky Way such as had not before existed. Indeed, it is safe to say that little or nothing was known of the structural peculiarities of the Milky Way before these photographs were made. Visual means, on account of the smallness of the field of view, could give only the vaguest and most uncertain ideas of its wonderful structure. But the extended views given us by the wide field of the rapid portrait lens, place before us the Milky Way in all its sublimity. Every rift and chasm is shown ; the cloud forms, the great nebulous regions, and the singular alignments of stars, are all faithfully portrayed for permanent study. It is through the study of these details that we shall ultimately know something definite concerning the universe of stars in which our own Sun is placed.

For the study of the phenomena of the tails of comets, the portrait lens has shown itself most admirably suited. It has added an interest to the physical study of these bodies that did not exist previously ; for the most interesting of the phenomena shown by comets must always escape the visual observer and pass unknown, without the aid of the portrait lens and the photographic plate. Unlike the planets, the comets often traverse the entire solar system. They are, therefore, our only means of exploring the regions between the planetary orbits. Instead of ponderous bodies like the planets, they are but flimsy creations of enormous dimensions. They are thus likely to be easily subject to disturbances in their forms that would produce no perceptible effect on their motions. What these influences may be we do not know ; probably swarms or streams of meteors, which we know do exist in space, or possibly some other cosmical matter yet unknown. Such objects might be (and possibly have been) revealed to us by their effect upon the form of the comet's tail as it sweeps through space.

Swift's Comet of 1892.

This was the first comet to show to the photographic plate the extraordinary changes to which these bodies are subject. Indeed, if it had not been for the photographic plate we should have known nothing of the extraordinary changes that occurred in this comet and several that have since appeared.

Photographs taken April 4 and 5 showed that very rapid changes were taking place in the comet ; these changes seemed to culminate in the extraordinary phenomenon of April 7.

A study of the various photographs of this comet would seem to show that the observed phenomena can readily be explained by

disturbances in the nucleus, and by the ejection of the matter composing the head in a direction away from the Sun.

1892 April 6^d 15^h 30^m—16^h 35^m. (Lantern slide.)

In this photograph there is no resemblance to the appearance of the comet on preceding dates.

The tail consists of two broad streams, the northern of which is very bright, and the southern faint. The two streams merge together near the head, and at this point there is a quick bend in its southern side. A great deal of detail is shown in the brighter component in the form of bright streaks and patches. Fine threads or short "whisker tails" extend back from the head at considerable angles to the main tail. There are some indications present also of the remarkable disturbance which followed some twenty-four hours later.

1892 April 7^d 15^h 45^m—16^h 35^m. (Lantern slide.)
R.A.S., No. 10.

This picture shows a remarkable development in the tail at the back of the head, which might be taken for a secondary comet with a system of tails of its own. This singular development appears on one of a series of thin strands into which the tail has separated. This particular strand is the largest and brightest and somewhat curved, and becomes suddenly thinner near the head. These phenomena are very beautifully shown on the photograph. The large mass or secondary comet was doubtless thrown off from the nucleus or head some time during the preceding twenty-four hours, and must have had a very considerable velocity.

1892 April 24^d 13^h 50^m—16^h 10^m. (Lantern slide.)

This is a generally characteristic view of the comet. The tail partially separates into a number of streams, and on the north side is very sharply defined by what appears to be a thin black rift; if this edge of the tail is continued to the comet, it will pass south of the centre of the head, and consequently does not appear due to a force at that moment seated in the nucleus. The south portion of the inner bright tail is irregular near the head, and in this resembles some of the peculiarities of the tail of April 6.

1892 April 26^d 13^h 45^m—16^h 10^m. (Lantern slide.)

The multiple structure of the tail is well shown. It appears to be made up of a number of bright strands which centre in the head.

Holmes's Comet and the Andromeda Nebula.

1892 November 21^d 8^h 55^m—10^h 10^m. (Lantern slide.)

The apparent motion of the comet was so slow that it was possible to obtain a sharp picture of both comet and nebula—a circumstance that is not likely to happen again soon.

The short exposure (75^m) for this picture shows splendidly the rapid action of the portrait lens. Nearly everything that is usually shown in long exposure photographs of the nebula is brought out very clearly with this comparatively short exposure. There is a bright speck in the comet near its preceding edge; this, however, was a fixed star, and not the nucleus, as might be supposed.

An earlier picture, November 10, shows the comet round and sharply defined like a planetary nebula, with a symmetrical nebulous atmosphere surrounding it for some distance. That photograph also shows an irregular nebulous appendage about a degree to the south-east of the comet and attached to it by a hazy connection. This particular photograph (a copy of which is in the possession of the *R.A.S.*, No. 17) is very suggestive, taken in connection with the collision theory offered by several astronomers to account for the sudden appearance of this body. It was suggested that the object was not a comet in the ordinary sense of the word, but the result of a collision of two asteroids, for the orbit seemed to lie in the asteroid zone. The failure to see the comet previous to its sudden apparition near the Andromeda Nebula, its uncometary appearance, its peculiar freaks, and final utter disappearance from the heavens, connected with the nebulous appendage shown in the photograph of November 10, would strongly suggest that the object was not a comet at all, but more probably a result of some celestial accident. I think there is no question but this "comet" will never be seen again, and doubtless before now it has ceased to exist as an individual body.

I do not wish it to be understood that I endorse the theory that the apparition of this object was due to the collision of two asteroids. It may have been due to something besides the collision of one asteroid with another. We know too little about what may really exist in that region besides the individual asteroids themselves. Certainly many of the phenomena presented by this body were entirely uncometary. In some of the stages of its existence, however, its appearance was perfectly cometary. I have a photograph of it on December 10, when its diameter was about $\frac{1}{2}$ degree. It was a well developed comet then, with a nucleus and central brightness and a diffusion of the head away from the Sun. This is a beautiful picture, and the stars shine through the comet everywhere. A month later, after it had become excessively faint and diffused, it suddenly (1893 January 16) assumed the form of a bright nebulous star, and again underwent a process of expanding and diffusion, and finally disappeared.

1893 *Brooks's Comet.*

Photographically this was the most remarkable comet that has yet appeared. It is scarcely necessary to say that had it not been for the photographs obtained of it with the Willard lens, we should have known nothing whatever of the extraordinary phenomena which were presented by this body, and which I am convinced will some day be seen to have a bearing upon a problem outside of that of the comet itself and of the highest importance to astronomy.

I have selected five of the photographs of this comet for description, four of which bear directly upon the subject just mentioned.

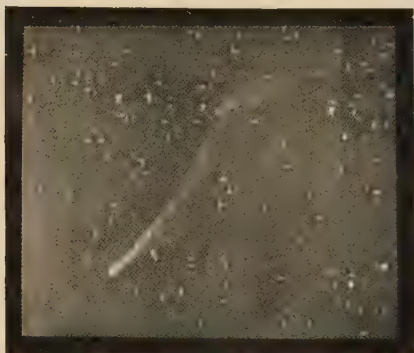
1893 October 20^d 16^h 35^m—17^h 10^m. (Lantern slide.)
R.A.S., No. 14.

This picture shows the tail straight, but gradually widening, and diffused more or less to the north. From the northern side of the head a short diffused tail stretches out for half a degree or more, at an angle of some thirty degrees to the main tail. The apparent motion of the comet was in a direction nearly perpendicular to the length of the tail towards the north-east, and this is the direction from which the disturbance seemed to come in the later pictures.

1893 October 21^d 16^h 37^m—17^h 12^m. (Lantern slide.)
R.A.S., No. 9.

There is an utter transformation of the comet in this picture. The tail is larger and brighter and very much distorted, as if it had encountered some resistance in its sweep through space. This disturbance seems to have disrupted the north-east edge of the tail. The small side tail has apparently been swept away, while the more distant portion of the main tail is streaming in a very irregular manner. The entire picture is highly suggestive of an encounter with some sort of resistance. Is it possible the tail passed through a stream of meteors such as we know exist in space? Whatever the cause may have been, the appearance of the tail utterly excludes the idea of the phenomenon being due to irregular emission of the matter from the nucleus—an explanation quite satisfactory in the case of Swift's Comet.

In passing, this particular photograph seems to explain at least one of the ancient descriptions of a comet, viz., "a torch appeared in the heavens." The comet, as shown in the photograph, is sufficiently suggestive of a torch streaming irregularly in the wind.



BROOKS'S COMET, 1893 November 2^d 16^h 10^m—17^h 25^m.



BROOKS'S COMET, 1893 November 11^d 15^h 58^m—17^h 35^m.

1893 October 22^d 16^h 30^m—17^h 12^m. (Lantern slide.)
R.A.S., No. 13.

The tail appears a total wreck in this photograph, and is still more suggestive of a disaster. It is very badly broken, and on the south-west side hangs in irregular cloud-like masses. Near the extremity a large gap exists in the tail, as if something had gone through it from the north-east, and a large mass is torn off beyond this break and seems to be drifting independent of the comet. Several of the other photographs which I obtained of this object show similar masses disconnected from the tail.

1893 November 2^d 16^h 10^m—17^h 25^m. (Lantern slide.)
(Plate 5.)

This is, perhaps, the next most remarkable picture of this comet, and shows that it was still in a disturbing region. The tail looks as if it were beating against a resisting force, and it seems to be encountered—as in all the photographs—on the advancing side of the tail. The motion of the comet was perpendicular to the tail towards the east, and, as will be seen, this is the direction from which the resistance seems to come. At one point the tail is nearly discontinuous, and at the end it is turned off abruptly nearly at right angles, as if at that point a greater current of resistance was encountered.

One or two other photographs show the tail badly broken and drifting in irregular fragments through space. These four pictures, however, are sufficiently characteristic of the phenomena shown by this comet to strongly suggest the idea that the tail must have encountered some form of resistance in its journey around the Sun, in this part of the heavens, on or about October 21, and at other times subsequent.

1893 November 11^d 15^h 58^m—17^h 35^m. (Lantern slide.)
(Plate 5.)

In this photograph, the tail of the comet is straight. It consists, at some distance from the head, essentially of two branches. The western branch is sinuous, as if matter were streaming irregularly back from the head, while the northern is very straight. At the end of the tail is a condensation which is nearly separated from the main tail.

A slender thread of light, beginning in the hinder part of the tail, stretches nearly to the end of the tail and forms the western border of the diffused western part of the tail. Near the head of the comet the tail is very slender and there are several small whisker tails from the rear of the head.

There is a small meteor trail crossing the south-western part of the plate parallel to the comet's tail.

1893 November 13^d 15^h 25^m—17^h 30^m. (Lantern slide.)
R.A.S., No. 61.

This photograph perhaps properly belongs to the set of meteor pictures.

In the original negative the tail of the comet is shown in a straggling manner for some distance beyond the bright star (*a Can. Ven.*)

Perhaps the most singular thing about this picture is the fact that, though it was made on the morning of November 14, when there was a considerable number of bright Leonids, the great meteor shown on the plate was not a Leonid, for it was coming from the north, approximately towards the Leonid radiant. The meteor was seen with the eye as it shot across the sky and burst just off the region of the plate, but unfortunately the exact time was not recorded. It would not, however, be far from the middle time of the exposure. It was very brilliant—brighter than *Venus* at her greatest brilliancy.

Photographic Discovery of Comet V., 1892.

1892 October 12^d 6^h 40^m—11^h. (Lantern slide, enlarged.)

$$\alpha = 19^{\text{h}} 32^{\text{m}}; \delta = +12^{\circ} 50'.$$

This comet was the first one to be discovered by the photographic plate. A photograph north and west of *Altair* was made, in my regular work of photographing the Milky Way. When the plate was developed and examined, a short hazy trail was found on it in $\alpha = 19^{\text{h}} 32^{\text{m}}$, $\delta = +12^{\circ} 50'$ (see *A.J.* 277). It was at once seen that the object was a stranger, as I was perfectly familiar with that part of the sky. It was too late to look it up that night with the telescope, but the next night it was sought for and found to be a very faint comet moving to the south-west. The discovery was telegraphically announced and the comet was generally observed. The orbit proved to be of short period—about $6\frac{1}{2}$ years.

Gale's Comet, 1894.

1894 May 5^d 8^h 45^m—11^h 15^m. (Lantern slide.)

This is a characteristic photograph of the comet, which was mainly remarkable for the slenderness of its tail.

In this picture the tail is thread-like for some distance from the head. Further away it broadens out slightly, and separates into two or more parts. The northern edge of the tail appears to have a double curvature.

The phenomena presented by this comet were not very striking, though the changes in the tail were interesting. Only very slight traces of the tail could be seen with the telescope, and

these only quite close to the head, which was large and round, and did not seem to have anything to do with the formation of the tail, that is, there was no indication of the customary blending of the head into the tail.

PHOTOGRAPHS OF METEORS.

A nearly stationary meteor, 1894 August 9^d 14^h 17^m 4^s.
(Lantern slide.)

This is the time of the meteor's appearance. It was nearly stationary, with a short path about 12' long. The motion was from the north-east to the south-west. The original plate shows two other fainter meteors.

A number of other meteors were photographed at different times during my work at Mount Hamilton, but this stationary meteor and the one shown on the photograph of Brooks's Comet, 1893 November 13, are the most remarkable.

1897 August 10^d 15^h 19^m—15^h 49^m. (Lantern slide.)

This photograph was obtained with the Clark 3·4-inch doublet, which was kindly lent by the family of the late Alvan Clark, and which is a miniature of the Bruce 24-inch, and made from the same glass as that lens. The full flight of the meteor is shown on the plate. Before disappearing it burst, and beyond this point it left a faint trail as it died away. This gives the trail the appearance of a long shafted lance. Its path extends from $\alpha=2^h 59^m$, $\delta=+32^\circ$ to $\alpha=2^h 59^m$, $\delta=+23^\circ$.

1897 August 10^d 15^h 19^m—15^h 49^m. (Lantern slide.)

This is the same meteor. The picture was made with a small lantern lens 1·6 in diameter belonging to Professor Hale.

This photograph not only shows the meteor train, but it also shows the Pleiades near the lower east part of the plate. It is a very beautiful picture apart from its scientific value. These two photographs were made at the Yerkes Observatory.

These meteor photographs were reproduced and fully described in *Popular Astronomy*, No. 46.

PHOTOGRAPHS OF THE MILKY WAY.

Star Cloud in Sagittarius.

1892 June 29^d 9^h 25^m—13^h 55^m. (Lantern slide.)

$\alpha=18^h 10^m \pm$; $\delta=-20^\circ$.

This plate shows a large star cloud in Sagittarius, remarkable for the two black holes in it. Running southwards from the larger and more definite of these holes is a semi-vacant region, which

branches out into two more or less regular semi-vacant lanes, which run for nearly a degree and a half from the hole. At the junction of these lanes, about 50' from the hole, is a remarkable thread-like stream of small bright stars which extends about 20' east and west. Curving slightly at its east end this line of stars makes a V-shaped connection with two or three other bright stars. At the southerly ends of the dark lanes are two delicate, thread-like streams of stars; the southern one of these extends in a gentle curve for nearly $1\frac{1}{2}$ degree. This is a very striking phenomenon. A similar stream runs eastwards from near the upper part of the black hole. Indeed, this is a remarkable region for star streams, many of which can be picked out on this plate. In the northern part of the slide is shown the celebrated Omega Nebula, which loses its characteristic appearance on account of the greater extent of nebulosity which the photograph shows compared with what the eye sees. The nebulosity extends in a very diffused, fan-shaped manner for over half a degree to the eastward from the brighter portion.

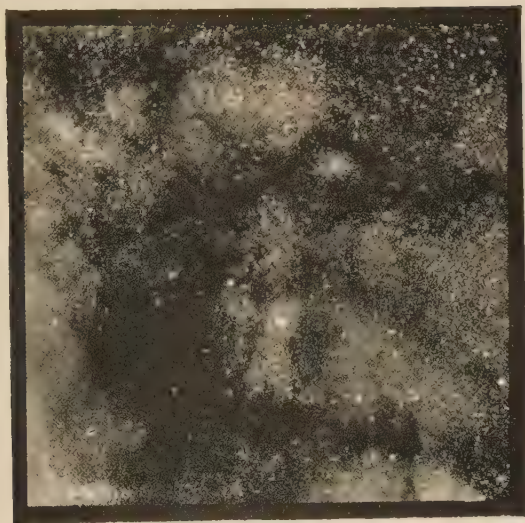
About $1\frac{1}{2}$ degree south of the black hole is a group of nebulous stars. The largest star of this group is surrounded with a circular nebulosity some 20' in diameter. Three degrees south of the hole is a bright star, with a partial ellipse of small stars extending south-eastwards from it. There are many other remarkable features about this plate, which will be at once apparent to the eye.

Near θ Ophiuchi.

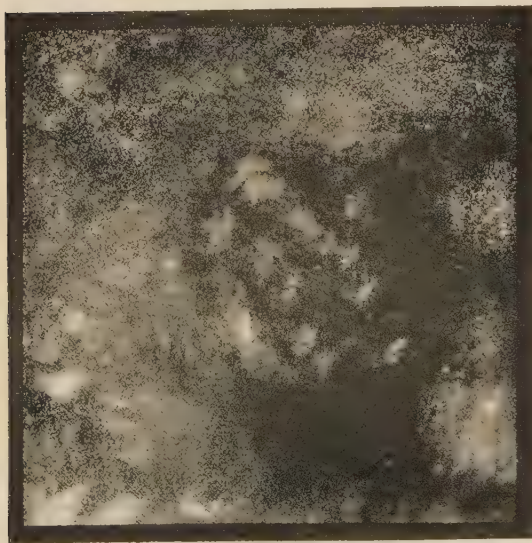
1894 July 6^d 9^h 30^m—13^h 5^m. (Lantern slide.)

$\alpha = 17^{\text{h}} 15^{\text{m}}$; $\delta = -25^{\circ}$. (Plate 6.)

This is certainly one of the most remarkable regions of the Milky Way. One would hesitate before coming to a conclusion as to what the ground work here is. Whether it is stars altogether, or some nebulosity, or something else, which is neither stars nor nebulosity (for it does not closely resemble either), it would be difficult to decide in one's mind. Besides the bed work of small stars, there seems to be possibly an infusion of nebulous matter over a large portion of the sky in this region. To the east and south of θ Ophiuchi is a vast chasm or rift in the sheetings of stars. This has a ragged but definite appearance on its western edge, but is more diffused to the east. To the west of the star θ will be seen an extended mass of diffused matter among the stars, which runs southward and partly bridges the western branch of the great rift. At the extreme western end of this rift—beyond the hazy diffusion—the vacancy has dark spots in it. Similar appearances occur at different points in this part of the sky. One can scarcely conceive a vacancy with holes in it, unless there is nebulous matter covering these apparently vacant places in which holes might occur. The appearance is somewhat like what



MILKY WAY NEAR θ OPHIUCHI, 1894 July 6^d 9^h 30^m—13^h 5^m.



THE REGION OF δ OPHIUCHI, 1895 June 26^d 10^h 10^m—14^h 15^m.

is sometimes seen in the umbra of a sunspot, in which yet blacker holes appear. North of θ are several minute black markings, one of which very much resembles the letter S or the figure 5. Two almost parallel semi-vacant streaks, running north and south, will be seen on each side of θ . Still farther north of θ the Milky Way presents a broken appearance, with numerous holes and rifts. These all show the peculiarity of darker interiors. This is specially shown in another photograph I have made with that region central.

This picture is suggestive of a breaking up or segregation of the stratum of stars and nebulosity—I am not sure it is nebulosity—in this portion of the Milky Way.

North of θ Ophiuchi.

1895 June 25^d 9^h 55^m—13^h 55^m. (Lantern slide.)

$$\alpha = 17^{\text{h}} 15^{\text{m}}; \delta = -22^{\circ}.$$

This photograph shows still better some of the phenomena of the preceding picture. It brings out yet more remarkably the extraordinary nature of the holes and rifts in this part of the Milky Way. The phenomenon of darker holes in the vacancies is strikingly shown, and looking at the picture one cannot repress the thought that all this region of the Milky Way must have a substratum of nebulous matter mixed in freely with the ground work of stars.

The Region of 58 Ophiuchi.

1895 June 26^d 10^h 10^m—14^h 15^m. (Lantern slide.)

$$\alpha = 17^{\text{h}} 35^{\text{m}}; \delta = -22^{\circ}. \text{ (Plate 6.)}$$

This region joins on to the preceding one. It is quite unique, however, and the peculiar appearances shown on this plate are not repeated in any other part of the Milky Way.

The bright star in the middle of the slide is 58 *Ophiuchi*. This star occupies the centre of a most remarkable region of small, cloudlike masses, which in arrangement seem to have a slight spiral tendency. This region, like that of θ *Ophiuchi*, is one where some doubt as to the existence of slight nebulosity might arise. I do not feel certain, however, that these clouds are nebulous, for there is lacking that peculiar soft appearance always characteristic of the true nebulosities of the sky.

The Trifid Nebula and M. 8 are shown at the east edge of the plate. The cluster in the north-east quarter is M. 23.

This plate also shows the trail of an asteroid, which Dr. Berberich kindly identified as belonging to *Euterpe* (27), which was discovered in 1853 by Hind. To those interested in this planet the trail will be found $1\frac{1}{2}$ degree south of 58 *Ophiuchi*.

It will be easily found on the large 10×8 glass positive in the possession of the Royal Astronomical Society, which is from the same negative as the present lantern slide. Indeed, it can be picked out on the slide with a magnifier, 0.32 inch almost due south of 58 Ophiuchi , in a semi-vacant region, between two of the clouds.

The Nebulous Region of 15 Monocerotis.

1894 February $1^d 7^h 0^m - 9^h 25^m$, clouds then $9^h 50^m - 10^h 25^m$.
(Lantern slide.)

$$\alpha = 6^h 35^m; \delta = +10^\circ.$$

This plate shows well the large diffused nebulosity that extends some 3 degrees northwards from the condensed region about 15 Monocerotis . The nebulosity spreads over and partly veils a portion of the great vacancy which lies north and west of 15 Monocerotis . To the west of 15 Monocerotis is a curious nebula involving several considerable stars. In the upper part of this nebula are one or two remarkably small black holes. This object, which is extremely faint and diffused visually, was discovered with the 12-inch in 1888. The position of this nebula is $1860.0 \ 6^h 23^m 27^s + 10^\circ 7'$. It involves the two D.M. stars $+10^\circ 1159$ and $+10^\circ 1160$. Close north of this nebula is a small nebulous star which was also discovered with the 12-inch in 1888. Its position is $1860.0 \ 6^h 23^m 14^s \pm, +10^\circ 32' 6 \pm$. There is also a small vacancy in the nebulosity about this star, close south of the star.

At the south edge of the plate is shown a portion of Swift's nebula N.G.C. 2237.

If the plate is carefully examined, many curious lines of stars, vacant lanes, &c., will be seen. About 2 degrees south of 15 Monocerotis is one of these thin lanes or dark lines among the stars which, though extremely narrow, runs eastward for about 2 degrees.

Region of M. 11.

1895 August $16^d 8^h 25^m - 13^h 35^m$. (Lantern slide.)

$$\alpha = 18^h 45^m; \delta = -6^\circ.$$

This magnificent star cloud is beautifully shown on this plate. It was one of the first of the Milky Way clouds photographed in 1889.

The small cluster M. 11 lies on the upper or north edge of the neck of the large cloud, and looks like a nucleus. The western side of the great cloud has several rather sharply marked indentations and several detached masses of stars.

The star 6 Aquilæ , on the upper north edge of the great head, has two curious sprays of stars extending from it, giving the

appearance of a ram's horns. The great star cloud seems to be made up of very small stars, apparently very uniform in size. Near the left-hand corner of the plate is shown a beautiful bright nebulous star. This is S.D.M. $10^{\circ}47'13''$ of the 5.5 magnitude. The position for 1855.0 is $18^{\text{h}} 23^{\text{m}} 23.9^{\text{s}}$, S. $10^{\circ} 53'4''$. The nebosity about this star is somewhat elliptical. It was discovered on the plates of 1889, and is quite noticeable visually (See *Ast. Nach.* 3111, Bd. 130.) The bright star near the N.E. edge of the plate is λ *Aquilæ*. The great star cloud seems to stretch out to and surround this star.

Region of M. 8 and the Trifid Nebula.

1895 June 27^d $10^{\text{h}} 55^{\text{m}} - 14^{\text{h}} 25^{\text{m}}$. (Lantern slide.)

$$\alpha = 18^{\text{h}} 0^{\text{m}}; \delta = -24^{\circ}.$$

This slide is intended to show the appearance of the Milky Way in the immediate neighbourhood of these two nebulae. It gives an excellent idea of the apparent relation they bear to the rest of the Milky Way. They appear to lie just free of the western border of a very brilliant portion of the Milky Way, in a partially vacant region, between the bright clouds and the region of 58 *Ophiuchi*. South of these objects is one of the most beautiful of all the regions of the Milky Way.

M. 8 and the Trifid Nebula.

The same as the preceding, on a larger scale.
(Lantern slide.)

This is intended to give a closer view of these objects, and to show their relation to each other and to a group of nebulous stars which lies about 1° east of M. 8. The latter is a very remarkable group. The stars are not simply involved in nebosity, but each one is a distinct nebulous star. They are connected on the photographs by a delicate nebulous strip with M. 8. Several of these were originally discovered visually with the 12-inch.

In reference to this picture it is well to note one thing which might be misleading when compared with photographs of these objects with larger instruments, where the scale is greater. In dealing with the fainter and outlying portions of M. 8 the portrait lens is eminently suited, but for the details of the brighter parts a larger scale becomes necessary. These details are too crowded with the small scale, and the light action is so great that what are apparently vacant lanes and regions with a larger instrument are filled up and obliterated with the long exposure, thus producing an apparent difference in the appearance of the nebula with the portrait lens and with a greater telescope. For the details the difference is in favour of the larger telescope for a truthful representation of the nebula; or,

in other words, the small bright details of this nebula are not suitable subjects for a short-focus portrait lens, especially when using such long exposures as are required to bring out the fainter portions of the Milky Way. A comparatively short exposure would show these details more faithfully.

Great Star Cloud in Sagittarius.

1895 August 13^d 8^h 0^m—11^h 8^m. (Lantern slide.)

$\alpha=17^{\text{h}} 56^{\text{m}}$; $\delta=-28^{\circ}$. (Plate 7.)

This is a superb picture of the Milky Way. It most emphatically shows the great value of the portrait lens for work of this kind, where large details, covering a great region, are to be dealt with.

This beautiful region has always had a special charm for me, and I have secured a great many photographs of it. It was the first region to be photographed in 1889.

I can hardly believe that any one familiar with the sky can look on this picture without admiring the beauty of structure and detail shown on it. Outside of its scientific value, it is a picture in itself.

To the west of the centre is a great plume-like spray of stars that apparently is connected with a long rope-like nebula and streak of stars running nearly north and south for nearly 2 degrees. This nebulous rope of stars is a very singular feature. In some photographs of the region which I made with the small lantern lens it seems to stand out from the other details near it as if it were considerably nearer to us and not connected with the star plume, as it appears to be in this photograph.

In the bright region near the centre of the plate is a tiny black hole about 2' or 3' in diameter, well defined, and close preceding a small bright group of stars. It is so small and well defined on the plate as to look like a defect. The position of this object is $17^{\text{h}} 56^{\text{m}}-27^{\circ} 51'$ (see *A.N.* 2588). It is a most remarkable object, with a low power on a 5 or 6-inch telescope. In examining this hole with the 36-inch, I found that its southern edge was made up of a dense mixture of milky nebulosity and small stars.

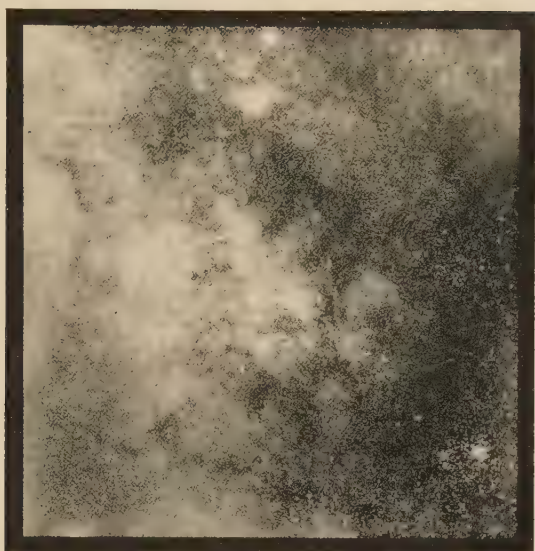
In the north part of the plate is shown M. 8 and the Trifid Nebula.

The Great Nebula of ρ Ophiuchi and the Vacant Regions near Antares.

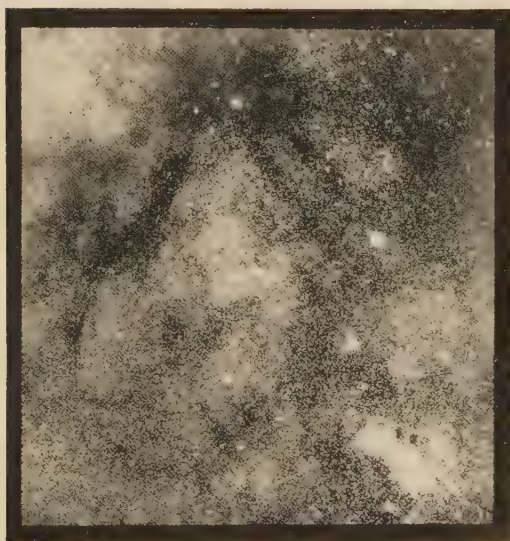
1895 June 21^d 9^h 12^m—13^h 12^m; June 22^d 9^h 5^m—13^h 35^m.
(Lantern slide.)

$\alpha=16^{\text{h}} 20^{\text{m}}$; $\delta=-23^{\circ}$.

It is very difficult to attempt a description of this picture. In the centre of the plate is the great nebula, in the centre of which ρ Ophiuchi is apparently placed. But this is only the



GREAT STAR CLOUD IN SAGITTARIUS 1895 August 13^d 8^h 0^m—11^h 8^m.



REGION NEAR THE OMEGA NEBULA (M. 17), 1895 July 25^d 9^h 35^m—14^h 0^m.

main condensation of this remarkable nebula. Its influence seems to be very far-reaching, as it has secondary condensations about at least two other stars, viz. Cordoba D.M. $24^{\circ}12683$ and $24^{\circ}12684$ and 22 *Scorpii*. The one about the Cordoba stars is the most striking, and seems to be made up of four curved streams, like the whirls of a great spiral. The great condensation about ρ *Ophiuchi* is most highly suggestive, and with a larger telescope would, no doubt, prove to be a most extraordinary object, as there are a great many remarkable details shown even on this small scale.

The great nebula occupies a vacant region from which vacant lanes stretch irregularly for great distances to the east. One remarkable feature about these dark lanes is the peculiarity before mentioned, of darker places in the vacant regions; this is strikingly shown in the present photograph. A nebulous prong is seen extending northwards for a short distance from the bright star, σ *Scorpii*, which is evidently connected with the great nebula. A large portion of the sky here seems to be covered with diffuse nebulosity, to which belongs the condensation about ρ *Ophiuchi* and the other stars. The peculiarity of this region has suggested to me the idea that the apparently small stars forming the ground work of the Milky Way here, are really very small bodies compared with our own Sun. (See *Popular Astronomy*, No. 45, where the subject is discussed in detail.)

In the upper north-west corner of the picture is the star ν *Scorpii*, which is seen to be involved in a singular wing-like nebula. East and south of ν are the two stars S.D.M. $19^{\circ}4358-9$ and 4361 , which are involved in dense nebulosity. The star 4361 is in the position $1855^{\circ}0$ $\alpha=16^h 12^m 1^s$; $\delta=-19^{\circ}46'$.

These objects were none of them known previous to the first photographs I secured of this region in 1895 March, with the exception that I had known of nebulosity in this region for many years through my comet sweeping.

I am glad to hear that Professor S. I. Bailey expects to take this great nebula up with the Bruce 24-inch at Arequipa, at its next apparition, as well as several other objects of this kind. The results will be exceedingly interesting.

The Nebula about ν Scorpii.

1895 May $23^d 9^h 0^m-12^h 20^m$. (Lantern slide.)

$\alpha=16^h 5^m$; $\delta=-19^{\circ}$.

ν *Scorpii* is one of Mr. Burnham's double stars. In photographing the region of the great nebula of ρ *Ophiuchi* in 1895 March, I made exposures at the same time with the $1\frac{1}{2}$ -inch lantern lens. On the photographs, with this small lens, the star ν *Scorpii* was seen to be involved in dense nebulosity. This star fell at the edge of the Willard lens plate, but upon examination it was seen

that the larger lens had also shown the nebulosity, and this was repeated in subsequent pictures. The present plate is from a negative made with the Willard lens specially to show the nebula. It is seen to be a wing-like nebulosity, extending north, west, and south-east, with the bright star occupying, apparently, the centre of brightness. The nebula extends eastwards for some distance, where it seems to dull the sky, or where there are very few stars. It is well defined and brightest at its western edge. The photographs indicate that this nebula is probably connected with the great nebula of ρ *Ophiuchi*.

Region of β Cygni.

1893 October 12^d 6^h 52^m—11^h 35^m. (Lantern slide.)

$$\alpha = 19^{\text{h}} 25^{\text{m}}; \delta = +26^{\circ}.$$

This picture shows the cloud forms in the Milky Way, south and east of β *Cygni*.

Some 5° east of β the dense clustering of small stars rather abruptly terminates in great cloud masses. Beyond this the Milky Way is very thin, and permits the darkness of space to be seen between the stars. One is specially struck with the apparent extreme smallness of the general mass of stars in this region.

Region near χ Cygni.

1892 October 20^d 6^h 47^m—11^h 47^m. (Lantern slide.)

$$\alpha = 19^{\text{h}} 40^{\text{m}}; \delta = +33^{\circ}.$$

This region lies south of γ *Cygni*, which is seen in the north-east half of the photograph.

The north-west part of the plate is covered with a more or less uniform sheet of small stars, so densely crowded as to intercept the view of space beyond, while the south-east portion is overspread with a very thin sheeting of stars projected against the blackness of space. The contrast between the two conditions is very beautiful and striking. The stars here are also remarkably uniform in size.

The original negative shows a great deal of nebulosity about γ *Cygni* in the form of brightish strips and patches, which slightly give the impression of a spiral arrangement to the nebulosity; these have been sacrificed, however, in the slide to show the structure of the Milky Way to the best advantage.

Nebulous Region near α Cygni.

1893 October 5^d 8^h 0^m—14^h 5^m. (Lantern slide.)

$$\alpha = 21^{\text{h}} 0^{\text{m}} \pm; \delta = +42^{\circ} \pm.$$

The plate shows the singular structure of the Milky Way at this point, and the great nebulosities that affect the sky in this

region. It will be seen that the greatest mass of nebulosity seems certainly to be mixed up with the stars, and conforms with the outline of the star masses at the edge of the greatest semi-vacancy. This region was first photographed by Dr. Max Wolf. The nebulosities are easily seen with almost any sized visual telescope when a low power is employed. I was for many years familiar with the nebulosity when seeking for comets, though I did not take it for real nebulosity. Indeed, this very nebulosity was discovered by William Herschel. In a list of great masses of diffused nebulous matter, in *Phil. Trans.* for 1811, pp. 273-278, he gives for number 44 of his list ($1800^{\circ}0\ \alpha=20^{\text{h}}\ 51^{\text{m}}\ 4^{\text{s}}\ \text{P.D. } 46^{\circ}\ 51'$), with the note: "Faint Milky Nebulosity scattered over this space; in some places pretty bright." He gives the size in declination as $0^{\circ}\ 59'$, and in right ascension $2^{\circ}\ 53'$, or 2.8 square degrees in area. This is undoubtedly the object shown on the photographs.

Region of N.G.C. 6475.

1894 June $26^{\text{d}}\ 9^{\text{h}}\ 5^{\text{m}}-12^{\text{h}}\ 10^{\text{m}}$. (Lantern slide.)

$$\alpha=17^{\text{h}}\ 45^{\text{m}}; \delta=-35^{\circ}\ 0'.$$

This beautiful cluster is partly in a brilliant knot or condensation of the Milky Way.

About 3° north-east of the cluster is a small semi-vacant comma-shaped hole with a considerable star in its centre. This hole is about $12'$ in diameter.

The Milky Way in Cepheus.

1893 October $13^{\text{d}}\ 8^{\text{h}}\ 20^{\text{m}}-15^{\text{h}}\ 20^{\text{m}}$. (Lantern slide.)

$$\alpha=21^{\text{h}}\ 35^{\text{m}}; \delta=+57^{\circ}.$$

Near the centre of this plate is a large and singular nebulosity, remarkable for the irregular dark lanes that run into and through it. My first knowledge of this nebula was its presence near the edge of another plate. The present picture was made specially to see what the object was. It was found, as shown, to be a fine but very singular-looking nebula.

To the extreme west of the plate, and north of the centre, are two small stars near each other. One of these is strongly nebulous. It is one of Mr. Burnham's double stars ($\beta\ 1140$), while the other star close following it is $\Sigma\ 2790$. The larger star south of the centre of the plate is $\mu\ \text{Cephei}$, while the one at the north edge is $\nu\ \text{Cephei}$.

*Region near the Omega Nebula (M. 17).*1895 July 25^d 9^h 35^m—14^h 0^m. (Lantern slide.) $\alpha=18^{\text{h}} 30^{\text{m}}; \delta=-15^{\circ}$. (Plate 7.)

This is a very interesting region. The centre of the plate is covered by a large mass of stars which converges to a point at a vacant region in the north part of the plate. Indeed, nearly all the masses of stars in this region seem to tend towards this great vacancy, as if its formation had something to do with their general arrangement. In this hole shines the beautiful nebulous star previously mentioned (S.D.M. $10^{\circ} 47' 13''$), which is perhaps better shown on this plate than on the others. To the south-west of the centre of the plate is the celebrated Omega or Swan Nebula (M. 17), and at the lower south-west corner is the fine star cloud, with the dark holes previously mentioned.

All the times given in these descriptions are eight hours slow of Greenwich, except the two plates made at the Yerkes Observatory, which are six hours slow of Greenwich. The positions given for all the pictures are only very roughly approximate.

It is perhaps well to state that in none of my work has any retouching been resorted to. Every photograph is free from any blemish of that kind, which, however it may be tolerated in a portrait of the human face (and it is destructive enough of truth there), should never be permitted to vitiate the value of an astronomical photograph. A defacing scratch, or a misleading defect, should be removed, but on no account should results be sought for that cannot be got by a skilful and straight development.

In conclusion, I wish to express my sincere obligations to Mr. G. W. Ritchey, of this Observatory, who has kindly and skilfully made for me nearly all of the lantern slides here presented.

*Yerkes Observatory, Williams Bay, Wisconsin :
1898 November.*

Errata in Professor Herschel's paper, vol. lix.

- Page 184, line 2 from bottom, *for* Dr. Downing *read* Mr. Denning.
 " 186, first column of the table, *for* 1680 γ *read* 1680 δ .
 " " heading of the second and third columns of the table, *for* Cometary
 " " " Appulse" (γ) *read* Comets' Node and Appulse.
 " 189, line 15, *for* 21 *read* 27.
 " 190, line 2 from bottom, *for* 117 *read* 177.

CONTENTS.

	PAGE
Fellow elected	327
Candidates proposed	<i>ib.</i>
Presents announced	<i>ib.</i>
Report of Sydney Observatory for 1898	328
W. Schur , Determination of the diameter and compression of the planet Mars from observations with the Repsold Heliometer of the Royal Observatory, Göttingen (second communication)	330
W. F. Denning , The radiant point of the April Meteors (<i>Lyrids</i>)	333
Royal Observatory, Cape of Good Hope, Nebulæ observed in 1898	339
Royal Observatory, Cape of Good Hope, Occultations observed during the Lunar Eclipse, 1898 December 27	340
W. de Sitter , On the use of the electric light for the artificial star of a Zöllner Photometer	341
W. G. Thackeray , The Greenwich meridian observations of <i>Polaris</i> , 1836-1893. with reference to personality, the value of the constant of aberration, and the star's parallax	345
Royal Observatory, Greenwich, Note on the diurnal variations of the nadir and level of the Transit Circle	351
E. E. Barnard , Photographs of Comets and of the Milky Way	354
Errata	370

